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KING ŚŪDRAKA

An Historical Study

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Summary : I. Introduction. II. Internal Evidence of the *Mk.* examined. (A) The Prologue—King Śūdraka's attainments, age, and end. (B) Religious condition. (C) Social condition. (D) Geographical data. (E) Miscellaneous details. (F) King Śūdraka and Cārudatta in Southern history. III. Some problems analysed. (A) The problem of the dual authorship, of Prākṛit, and of the plot of the drama. (B) The problem of the date of the drama. (C) The problem of some technical words. (D) The problem of Ujjain and the *aśvamedha* sacrifice.

I. INTRODUCTION

SANSKRIT literature abounds in fascinating problems which admit of an historical treatment. One of these is that relating to the age and authorship of the celebrated drama called *Mṛicchakaṭikā* (*Mk.*). We may briefly allude to the main theories propounded till now by Sanskrit scholars in regard to the age and identity of the author of the *Mk.* Some have placed him before Kālidāsa ; others, after Kālidāsa ; still others have identified him with Daṇḍin ; and, finally, he has been declared to be a mythical figure.

On the basis of one of the statements in the *Skānda Purāṇa*, king Śūdraka, the author of the *Mk.*, was made one of the Āndhrabhṛityas.¹ The fact that Rāmila and Somila,—the latter of whom is mentioned by Kālidāsa, and the former by Rājaśekhara along with Bhāsa—, composed a *Śūdraka-kathā*, is, as Keith remarks, significant of Śūdraka's legendary character in the time of those authors, which was "considerably before Kālidāsa."² Sylvian Levi discounted the thesis of Śūdraka's having preceded Kālidāsa.³

Sten Konow identified king Śūdraka with the Ābhīra ruler Śivadatta, who, or whose son Īśvarasena, overthrew the last of the Āndhrabhṛityas, and founded an era called the Traikūṭaka or the Kaḷacuriyā or the Cedi era, the first year of which was A.D. 249-50.⁴ The fact that Vāmana, a writer on rhetoric (III. 2. 4.), who has been assigned to the eighth century A.D., cites from the play *Mk.*,⁵ helps us to assign Śūdraka to a period earlier than, if not contemporary with, Vāmana himself. Pischel's attempt to attribute the *Mk.* to Daṇḍin⁶ has been discredited by Keith.⁷ We shall see later on in the course of this

¹ Wilson, *Works*, IX, p. 194 ; Keith, *The Sanskrit Drama*, p. 129.

² Keith, *ibid.*, pp. 127, 129.

³ Sylvian Levi, *Théâtre Indien*, I. p. 198.

⁴ Sten Konow, *Aufsätze zur Kultur- und Sprachgeschichte* : Ernst Kühn gewindet, p. 107 ff. On Īśvaradatta, read Fleet, *Dynasties of the Kanarese Districts*, p. 294.

⁵ Keith, *ibid.*, pp. 92, 128.

⁶ Pischel, *Rudrāṭa*, pp. 16 ff.

⁷ Keith, *op. cit.*, p. 128.

paper that there are more weighty reasons than those given by Keith, for rejecting the identification of Daṇḍin with king Śūdraka. We may note in this connection that Rājasekhara in his *Kāvyamīmāṃsa* (ninth century A.D.), places Śātavāhana before Śūdraka.⁸ This, however, runs counter to a later tradition as given in the *Viracarita* and by the younger Rājasekhara, to the effect that Śūdraka was the minister of Śātavāhana, from whom he received half of his kingdom including the capital city of Pratiṣṭhāna.⁹ This later tradition cannot be accepted in view of the fact that, according to the *Kathāsaritṣāgara*, the minister of Śātavāhana was Śarvavarman, the author of the grammar called *Kātantra*. Since Śarvavarman has been assigned to the end of the third century A.D.,¹⁰ the evidence of the *Kathāsaritṣāgara* may be utilized to disprove the later tradition as recorded in the *Viracarita* and by the younger Rājasekhara.

Rejecting all the above, Keith wrote thus :—"These references seem to suggest that Śūdraka was a merely legendary person, a fact rather supported than otherwise by his quaint name, which is absurd in a king of normal type. . . . To make history out of Buddha's death, say, 483 B.C., and the history of the third century A.D., is really impossible. Śūdraka is really clearly mythical as is seen by the admission that he entered the fire, for no one can believe that he foresaw his death-day so precisely or that the ceremony referred to is that performed on becoming an ascetic, or even that the prologue was added after his death ; if it had been it would have doubtless been of a different type. Still less can we imagine that he was helped in his work by Rāmilla and Somilla."¹¹

Before we proceed further with our study, we may just note that Keith's assertion that because a name appears to be quaint, it is absurd in a king of normal type, cannot be entertained on historical grounds. For not only have we Śūdraka as the name of a king but that of Pālaka as well in history. Thus, in the history of Assam, in the dynasty which is said to have been established by Nāraka, and which is supposed to have lasted from *circa* 800 to 1000 A.D., there is a ruler called Pālaka, who comes sometime after the king Śilasthambha.¹² As regards the other name, we have the name of Śūdraka among kings both in north and south Indian history. Thus king Śūdrakayya was a feudatory of the Rāṣṭrakūṭa monarch Kannara Deva, Akālavarṣa, in A.D. 968, governing the Kadambalige 1,000 country. One of the titles of this king, strange enough was "Ujjainī Bhujanga."¹³ There was another ruler of the same name Śūdraka in the history of northern India. He is credited with the founding of the short-lived dynasty of Gayā in about A.D. 1,000.¹⁴ These examples, therefore, are enough to show that the name Śūdraka was by no means either quaint or absurd in the history of India.

⁸ Rājasekhara, *Kāvyamīmāṃsa*, p. 50 (G. O. S.).

⁹ *Journal of the Bombay Branch of the Royal Asiatic Society*, VIII, p. 240 ; Keith, *op. cit.*, p. 129.

¹⁰ R. Shama Sastri, *Mysore Archaeological Report for 1926*, p. 27.

¹¹ Keith, *op. cit.*, pp. 129-130.

¹² Ray, *Dynastic History of Northern India*, I, pp. 246-247.

¹³ *Epigraphia Carnatica*, XI, Pl. 23.

¹⁴ Ray, *ibid.*, I, pp. 348, 386.

II. INTERNAL EVIDENCE OF THE MK. EXAMINED

(A) THE PROLOGUE

None of the above historical figures is of any use to us in determining the identity of king Śūdraka, the author of the *Mk.* Hence we have to examine the internal evidence of the drama in order to ascertain the identity of its author. In the prologue we have the following from the *Sūtradhāra* or the stage-manager :

“...the illustrious Śūdraka, of unfathomable spirit, a poet who was the best amongst the twice-born (Brahmans), having the gait of a powerful elephant and the eyes of a *cakora*, whose face was like the full orb of the moon and whose figure was excellent. And moreover Śūdraka knew the Rig Veda, the Sama Veda, mathematics, the arts of medicine and erotics, and the science of elephant-training; he recovered by the grace of Śiva eye-sight which was free from all disease; had his son installed with great pomp as king; he performed the *aśvamedha*; and after having attained the age of a hundred years and ten days, he consigned himself to the flames.” Then, again, we have the following: “There was a king they say, named Śūdraka, who was addicted to war and was free from blunders, who was the ornament of Vedic scholars and an ascetic; and who felt fascination for a personal encounter with enemy elephants.”

From the above we may select the following criteria in determining the age and identity of king Śūdraka :—

- (i) That he was the best among the twice-born (Brahmans);
- (ii) That he was a poet of no mean order;
- (iii) That he was of handsome appearance and of excellent figure;
- (iv) That he was a scholar in the Rig Veda and Sama Veda, and an ornament among Vedic scholars;
- (v) That he was a scholar in mathematics, fine arts, and erotics (lit. *vaiśikīn*, or the art of courtesans); and in elephant lore;
- (vi) That he lived for one hundred years and ten days;
- (vii) That he was given to warfare (*bāhu yuddha lubdha*);
- (viii) That he was fascinated by an encounter with elephants;
- (ix) That he installed his son on the throne;
- (x) That he recovered his eye-sight with the favour of the god Śiva; and
- (xi) That he performed the *aśvamedha* sacrifice.

Of the above eleven criteria, the decisive ones are the following six; those relating to the king's personal appearance, his caste, his knowledge of the Smritis, his long life, his continuous warfare, his knowledge of elephant lore and his delight in fighting with elephants. And among these decisive criteria there are two which may be said to be the most determining of all factors. These two are the extraordinarily long life which the king lived, and his expert knowledge of the elephant lore. Now all the six decisive criteria, and especially the two determining ones, are most admirably applicable to a ruler of the Deccan, whose achievements we shall briefly enumerate here. He was known as Śivakumāra I, commonly known as Śivamara I. His other names were Nava Kāma, Prthvi-Konguṇi, Śripurusa, and Śiṣṭhapriya. He belonged to the ancient Ganga royal house, and was the younger brother of the gallant king Bhūvikrama.

The epigraphs of king Śivamāra I enlighten us on many points of interest. Thus, for instance, the Hebbūru copper plates dated in about A. D. 700, contains the following eulogy of that ruler :—"His (Bhūvikrama's) younger brother, whose lotus feet were illumined with the brilliance of the myriad jewel-suns in the diadems of great kings bending down before him, the self-chosen lord of Lakṣmī, was named Nava Kāma, beloved by the good (*Śiṣṭha-priyali*), destroyer of the hosts of his enemies, his fame the theme of song. Established at the breast of Lakṣmī, he takes away the fame of Muraripu (Viṣṇu), desires the pure character of Rāma, assents to the doctrine of Manu revered by the wise ; an inexpressible terror to the world ; as a seducer of other's young wives he is a blameless Devarāja (Indra) ; how wonderful ! And what greater wonder there can be than the fruit of the affection of the good ? Whose history white as the fibres of the inner stalks of lotus, the Kinnaras hymn on Meru girded with gold, decorated with the stars as with flowers, and on the peak of Kailāsa marked with the lotus feet of the daughter of the mountain (Pārvaṭi), and on the Vindhya mountain surrounded with the woods fanned by gentle breezes from the Revā (Narmadā). In the inner courts of the palaces of kings hostile to whom the Kirāta women decorate their bodies with the nector from the temples of the elephants slain by him, and see delighted the reflection of their joyous embraces in the jewelled courtyards. By him (Śivamāra) whose cherished order was placed on the summit of the crown of many kings, the ruler over his enemies, a terror to the multitude of hostile kings . . ." ¹⁵

Granting for argument's sake, that the above description contains an exaggerated account of some details, let us see whether any of the criteria we have mentioned above can be made to agree with some of the statements given in the preceding description. On four points there is complete agreement between the description of king Śūdraka as given in the prologue of the *Mk.* and that given in the Hebbūru plates. These four points are the following :—(i) That the king was called Nava Kāma, evidently because of his handsome appearance and excellent figure. (ii) That he assented to the doctrines of Manu, and was beloved by the good, who were evidently those well-versed in the *śāstras* and *smritis*. (iii) That he was likewise well-versed in the science of erotics, which alone explains why in the Hebbūru plates the king is described as a "seducer of others' young wives" like Devarāja or Indra. And (iv) That he was given to warfare as the destroyer of the hosts of enemies, and as the terror to the multitude of hostile kings.

The statement in the Hebbūru plates that king Śivamāra was a follower of the doctrines of Manu is admirably corroborated by another record called the Śāligrāma copper-plate grant which is dated in the 39th regnal year of the same king Śivamāra I (=A. D. 709). In this record we have the interesting information that Śrīmat Konguṇi (*i.e.*, the illustrious Śivamāra I) was "the protector of the *varṇas* and the *āśramas* like Vaivasta Manu, able to defend the southern quarter." The fact that the king in the *Mk.* is described as an ornament among Vedic scholars, is likewise happily proved by the statement in the Śāligrāma

¹⁵ *Ep. Car.*, XII, Tm. 23, pp. 7-8. The word *Śiṣṭha* is understood by Patañjali in the sense of "the instructed." See Macdonell, *A History of Sanskrit Literature*, p. 23. But I adopt the meaning as given both by Rice and Shama Sastri.

record which states that the illustrious Konguni Muttarasa (Śivamāra I) granted to a learned Brahman named Bhūtaśarmā of the Kṛṣṇatreya-gotra and the Taittirēya śākhā, the village of Śāligrāma as a free gift, in the presence of certain high placed officials (named) and of scholars versed in the four Vedas (*caturvaidya*).¹⁶

The Hebbūru plates, however, do not enlighten us on the most determining factors in the identification of the author of the *Mk. viz.*, those relating to the longevity and the expert knowledge in elephant lore of the author. The omission of the first factor in the Hebbūru plates may be explained by the fact that this contemporary record was inscribed during the king's life-time, and almost fifteen years before his death. Therefore, it is futile to expect any reference to the king's longevity in the Hebbūru plates. As regards the second point relating to the mastery of the elephant lore, we must confess that its omission in this contemporary record is inexplicable except in the sense that the king had not yet written a work on elephants when that record was inscribed. But the detailed description of his glory having been sung by the Kinnaras on the mountain Meru, on Kailāsa, and on the Vindhya, explicitly points to his having done something which made him one of the most famous figures in the whole of India.

That king Nava Kāma, Śivamāra I, was, indeed, a celebrated person is proved by the consistent praise given to him in terms identical to those mentioned above, in records dated A. D. 762, 776, and in that dated about A. D. 900.¹⁷ These records belong to his successors, and in all these inscriptions the fact of his having destroyed hosts of his enemies being the theme of song, clearly indicates that some remarkable military achievements were to his credit. Now we know from other records, as well as those cited above, that it was during the reign of his elder brother Bhūvikrama that a great battle had been fought at Viḷanda, in which the Pallava king Narasimhapotavarmam was defeated, and that as a result of which the entire Pallava dominions had passed under the suzerainty of the Gangas. We know also that king Bhūvikrama's younger brother Nava Kāma had two Pallava princes as hostages in his charge.¹⁸ It is not unreasonable to suppose, therefore, that Nava Kāma had taken part in the great battle of Viḷanda, and that perhaps he might have been wounded in the eye. We confess that these are only assumptions for the present. However, there is no denying the fact that Nava Kāma Śivamāra I was a great warrior.

Direct proof of his having been a great soldier is furnished in two records. One of them is the Devarahaḷli stone inscription, written in Old Kannaḍa characters and language. This undated stone inscrip-

¹⁶ *Mysore Archeological Report for 1941*, p. 127 ff. Dr. Krishna, who has edited this record, is inclined to identify the royal donor with Durvinīta; but I identify him with Śivamāra I on the following grounds. Firstly, because of the distinctive epithet *Vridhdhārāja*, which was borne only by Śivamāra I; secondly, because, like Śivamāra I, the royal donor is described as "beloved of the subjects"; and thirdly, because both on historical and palaeographical grounds, as Dr. Krishna has ably shown, the record is assignable to the middle of the seventh century A.D. If we accept the detail of the 39th regnal year being correct, the record, in my opinion, will have to be dated to 670 + 39 = 709—which would fall by a few years below the age assigned to the record on purely palaeographical grounds. I do not believe this last detail is a serious flaw in our reckoning.

¹⁷ See *Ep. Car.*, IV, Gd. 47; IX Nl. 60; *M. A. R. for 1919*, p. 28.

¹⁸ Rice, *Mysore and Coorg from the Inscriptions*, p. 37.

tion rightly assigned on palaeographical grounds to the eighth century A. D., records the following, after giving the genealogy of the Ganga rulers till Śivamāra I—That while Konguṇi (Śivamāra I) was ruling the earth, Durvinīta Eṛeyappor besieged Kosarupulki; and that seventy soldiers of his army, hailing from the village of Upagoḷa broke the ranks of the enemy. For this brave action of theirs they received specified gifts of land. The Prince Durvinīta Eṛeyappor is rightly assumed by Dr. Krishna to have been the son of Śivamāra I.¹⁹ We identify him with the Prince Eṛeyanga, who is mentioned in another record as governing the Torenād, 500, the Kongalnād 2,000, and the Male 1,000 Provinces.²⁰ Incidentally we may note that in neither record is he explicitly stated to be the son of Śivamāra I. But this need not vitiate our identification, since the names Durvinīta as well as Eṛeyanga were borne by Ganga princes, and since it was customary for princes of the royal blood to be appointed over large provinces, prior to their assuming the reins of administration. The significance of our identification of Durvinīta Eṛeyappor with Eṛeyanga, the eldest son of Śivamāra I, and of the fact that that prince was placed over many districts as governor in the reign of his father, may be borne in mind, when we shall explain later on an intricate problem in the *Mk*.

We may now cite another record which refers to a war in the reign of king Śivamāra I. This is the *viragal* or hero-stone found in the village of Hire Madhure, and inscribed in Old Kannaḍa characters and language. On palaeographical grounds it has been assigned to the seventh century A. D. It commemorates the death of a gallant and learned follower of king Śivamāra I by name Bhānu Dāsa, when a subordinate named Kaṭtiarasar of the king, pierced (*i.e.*, fought) at Bāge-ūr. The brave soldier Bhānu Dāsa is given much praise; but we may note in particular the phrases,—which say that he was ever watchful regarding Manu (*Manujāgaran*), that he was a companion of victory (*jayamītran*), and that he was a deluder of the disloyal (*ūnaravaiśikan*), speak highly of the character of the followers of king Śivamāra I. The Bāge-ūr mentioned above was no other than Bāgūru in the Hosadurga tāluka, Chitaldroog district, where two more *viragals* referring obviously to the same battle, have been found.²¹

The other four criteria may now be examined. These refer to the king's community, his high poetical skill and knowledge of elephant lore, his fascination in fighting with elephants, and, finally, the length of his life. Of these we shall first dismiss the question of his community. It is now a well-known fact that the rulers of the ancient Ganga royal House belonged to the Kāṇvāyana *gotra*, and that, therefore, they may well be considered to have been Brahmans. We admit, however, that they have at the same time laid claims to a Solar descent, tracing their

¹⁹ *M. A. R. for 1930*, pp. 176-7.

²⁰ *Indian Antiquary*, XIV, p. 229; Rice, *Mysore and Coorg*, p. 37.

²¹ *M. A. R. for 1930*, pp. 118-120. Dr. Krishna assigns this record to the middle of the eighth century on palaeographical grounds. But there is no reason why it should not be assigned to the end of the seventh and the beginning of the eighth century. This would make it fall within the limits of king Śivamāra I. Another *viragal* assigned also to the eighth century A. D. by Dr. Krishna, has been discovered at Hire Madhure. See *M. A. R. for 1930*, No. 23, pp. 122-123. I do not wish to discuss this *viragal* here.

origin to Ikṣvāku.²² But we may concede to the Brahmanhood of the Gangas on the strength of an explicit statement in the records of one of the followers of king Śivamāra I, which is called the Ālūru copper-plate grant, and which we shall cite in detail in a later context in this paper. In this record dated in A. D. 798 issued by the Ganga prince Mārasimha, the latter is called "*a dvijeśa* (the moon and also a Brahman) not only in pleasing women of lotus eyes (and blue water lilies) but also in fixing his mind in Viṣṇu".²³

We pass on now to the next criterion—that referring to the high poetical skill and the knowledge of elephant lore of king Śivamāra I. In the *Mk* we have an admirable picture of a rogue elephant called the Post-breaker, running amock. It belonged to Vasantasepā (Act. II). The graphic description of a run-away elephant given in this Act could never have been written by a layman: only an expert who was well-versed in elephant lore could have pictured so minutely the doings of a rogue elephant. In other words, the author of the *Mk*., who incorporated this description of the havoc caused by the rogue elephant, seems to have known both the theory and practice of elephant lore. We assert that king Śivamāra I was such an expert in the science of elephants. The best proof in support of our statement is the discovery of a work on elephant lore written by that ruler. This work is called *Kalpanāratnam*, which deals with the characteristics of elephants.²⁴ It is written in Sanskrit by a ruler called Śivamāra, who could have been no other than the one mentioned above, since the second of that name, as we shall presently mention, wrote a different work on elephants dealing with a different subject. This work called *Kalpanāratnam*, therefore, proves the statement in the prologue of the *Mk*. that the king called Śūdraka was a master of the *hasti-śikṣā* (science of elephants). We shall see later on in this paper that the admirable example which king Śivamāra I had thus set in regard to the study of the science of elephants, was more than well maintained by his successors, three of whom wrote different treatises on elephants. If the hyperbolical statement in the Hebbūru plates, referring to the Kinnara women decorating their bodies with the nector from the temples of the elephants slain by king Śivamāra I, cited above, can have any meaning at all, it may be taken as a further proof to substantiate the statement made in the prologue of the *Mk*., that the king felt fascinated at the idea of a personal encounter with elephants.

The most conclusive proof of the identity of the author of the *Mk*. with king Śivamāra I is that relating to the longevity of the king. We have seen that in the prologue of the play, the king called Śūdraka is said to have lived one hundred years and ten days.²⁵ We have many examples of rulers in South Indian history who lived to a ripe old age. But we have very few instances of kings who completed one hundred

²² Rice, *Mysore and Coorg*, p. 30. In some records they are described as Kṣatriyas. *M. A. R. for 1920*, p. 28.

²³ *M. A. R. for 1924*, p. 78. See later on in this paper for a detailed discussion of this record.

²⁴ Kuppaswami Shastri, *Triennial Catalogue of MSS. in the Madras Oriental Library*, IV, No. 3791.

²⁵ Dr. V. G. Paranjpe translates this passage Thus—"A hundred years and ten" (Trans. p. 2.). This is inadmissible, since it would mean 110 years. The text clearly says—*Śatābdam-daśadinasahitam*, which refer to ten days and not ten years.

यस्य १०० + १० दिवस

years of life. Indeed, we may venture to maintain that we have only one instance of a ruler, who lived for full one hundred years. And that ruler was king Śivamāra I. This is proved by the Bāradūr plates of king Śivamāra I's grandson and successor Śrīpuruṣa II, issued in the first regnal year of the latter (A. D. 726). The Bāradūr plates are of the utmost importance in our identification of the author of the *Mk.* with king Śūdraka, since that record confirms almost all our assertions relating to the main criteria which we have adduced above, excepting that relating to the mastery of elephant lore.

The Bāradūr grant after praising the achievements of king Bhūvikrama, the elder brother of king Śivamāra I, continued thus :—"His (Bhūvikrama's) younger brother, waited upon by damsels of courage, knowledge, beauty, wisdom, reverence, and fame having made the kinsmen and subjects obey by granting presents and honours and by placing confidence, protector of the four castes according to the law as laid down by Manu and others, protecting his subjects as a father (*prajānām pitevanugrah*), a pleasing figure to all the four directions (*catur-dikṣu-prasanta vigrah*), having filled his own treasury by carrying off the wealth of the hosts of his enemies whom he defeated by his own valour, always a Yama for numerous thieves the hostile army who did not bend down, having consistently with the Smṛitis lived for a complete hundred years (*smṛiti-avirodhena varṣā-śatapūrnāyur*), was the illustrious (*śrīmat*) Pṛthvī Konguṇi Vṛddharāja Śrīpuruṣa, the second so named. He moreover, whose feet were illumined with the brilliance of the myriad jewel-suns in the diadems of the great kings bending down before him, the self-chosen lord of Lakṣmī, was named Nava Kāma, beloved by the good (*śiṣṭha-priya*), his fame in destroying the hosts of his enemies being the theme of song."²⁶

There are some considerations regarding the above Bāradūr grant which may be noted before we proceed further with our discussion. In addition to the fact that king Śivamāra I had along with his other names Pṛthvī Konguṇi, Śiṣṭhapriya, Nava Kāma, the other name of Śrīpuruṣa is very interesting, for this is the first record which tells us that that particular name (Śrīpuruṣa), which was supposed to have been assumed only by his grandson and successor Śrīpuruṣa II, had also been assumed by Śivamāra I. But for our purpose what is of special significance is the fact that in this record we have a fourth name of that ruler—Vṛddharāja (Old Monarch), which fits in very well with his extremely old age. In fact, this title of *Vṛddharāja* justifies fully the statement made in the *Mk.* that the king lived to a full hundred years. We have other records in which the same title is given to king Śivamāra I. But we shall not cite these documents here. It is more than a mere coincidence that in the drama *Mk.* there is a character, whose name has a striking resemblance to the above appellation of Vṛddharāja given to king Śivamāra I. This is the great friend of Cārudatta, by name Cūrṇavṛddha, who was also a friend of the Sūtradhāra or the stage-manager. We may hazard a guess that the similarity in the names Vṛddharāja and Cūrṇavṛddha was not so accidental as natural, since Śūdraka, whom we have identified with Śivamāra I, obviously wished to leave a clue behind him in regard to his own personality, which he did in the name Cūrṇavṛddha.

There is another detail in the Bāradūr grant which deserves a passing note. Śivamāra I is likened in that record to Yama for the "numerous thieves" (*taskarāntakaraḥ*) the hostile army who did not bend down.²⁷ Now we have a detailed account of stealing in Act III. It is permissible to assume that the king (Śivamāra I), who is likened to Yama for the numerous thieves of the hostile army, was well-versed in what then was (and is perhaps even now) considered to be the art of stealing! If this is allowed, the detailed description of stealing as given in the *Mk.* is intelligible, in the sense that it is a sort of an autobiographical detail relating to the study of that art by the king himself.

Finally, there is the objection raised by Keith in regard to the quaint name which appears, according to that great scholar, absurd in a normal king. In addition to the arguments which we have already given above concerning the historicity of the name Śūdraka, we may observe that it was an age when both rulers as well as people assumed pseudonyms. Thus, king Śivamāra I himself, as is well-known to students of Deccan history, signed all his royal documents as *śiṣṭha-priya* (beloved by the good), and never by any of the many names which he had—Nava Kāma, Prithvī Konguṇi, Śrīpurusa, and Śivamāra. If he could have thus made use of one pseudonym in regard to public documents and charters, there is no reason why he could not have made use of another pseudonym (*Śūdraka*) in a drama, where anonymousness whether in the past or in our own times, has added to the popularity and importance of authors, both at the hands of contemporaries as well as of posterity. The king's example of using pseudonyms was followed by his officials. Thus, we have the following pseudonyms of the royal scribes, who inscribed the orders of their monarchs, during this period: Citrāśrya, Śilāditya, and Viśvakarmācārya.²⁸ These officials merely followed an example set by their royal masters. We may remember in this connection that this anonymousness of king Śivamāra I was perhaps not a little responsible for the wide popularity which he enjoyed during his life time and afterwards, about which, as we have already seen, there is abundant proof in the records. It was not a vain boast which the royal scribes inserted in their records when they said that the Kinnaras sang the history of Śivamāra I on the mountains Meru, Kailāsa, and Vindhya, and that his fame had become the theme of song. Only an author of the rank and genius of Śūdraka, Śivamāra I, could have won for himself such an undying glory at the hands of his contemporaries and posterity alike.

Out of the eleven criteria with which we started our identification, we have accounted for eight, and not explained the remaining three which refer to the restoration of the eye-sight of the king, his placing his son on the throne, and, finally, his performing an *aśvamedha* sacrifice. Of these we have hinted at the possibility of the king's having lost his eye-sight in the great battle of Viṇḍa, which had been fought in the reign of his elder brother Bhūvikrama against the Pallava king Narasimhapotavarman. But in what manner king Śivamāra I recovered his eye-sight

²⁷ *M. A. R. for 1944*, pp. 66-68. Perhaps another autobiographical detail may also be detected in the Garden of Cupid's Temple (*Kāmadevāyatana-udyānāḥ*) (Act I) referred to by Samsthānaka, which might refer to one of the names of Śivamāra I—Nava Kāma.

²⁸ *M. A. R. for 1944*, p. 70; *Ep. Car.* XII, Tm. 23; VI. Mg. 36.

through the favour of the god Śiva, is a mystery. All the same his names Śivakunāra or Śivamāra and Nava Kāma strongly suggest that he was a devotee of that god, although we must confess that there is no proof forthcoming in regard to this assumption of ours. As regards his placing his son on the throne, we shall have to discuss this detail later on while analysing the historicity of the sub-plot in the *Mk.* We shall likewise refer towards the end of this paper to the detail of the *aśvamdeha* sacrifice.

The length of the reign of king Śivamāra I, whom we have identified with king Śūdraka, the author of the *Mk.*, may be fixed, before we proceed to discuss the other details relating to that drama. His known records do not enlighten us on the chronological limits of his reign. But we know that his grandson, who succeeded him, and who is called Śrīpuruṣa II, came to the throne in A.D. 726.²⁰ Accepting this date as that of king Śrīpuruṣa II's accession, we may safely assert that his grandfather king Śivamāra I lived from 625 till 725. But as to the date of the accession of Śivamāra I himself, we have to note when his elder brother Bhūvikrama reigned. The last date for king Bhūvikrama is A. D. 670. Therefore, king Śivamāra I's reign lasted from 670 till 725. That part of the *Mk.*, therefore, which was the work of king Śūdraka, has to be assigned to the last quarter of the seventh and the first quarter of the eighth century.

(B) RELIGIOUS CONDITION

King Śūdraka, therefore, was undoubtedly a monarch of the Deccan. Let us further substantiate this statement by examining the internal evidence of the *Mk.* We shall first turn to the religious condition as depicted in the drama, confining ourselves only to one religion—Buddhism. From the time the Shampooer decides to turn a Buddhist monk (Act II) to the last scene when Śarvilaka is given a high administrative post by Cārudatta (Act X), we have many details about Buddhism. Act VIII opens with the benedictions of a Buddhist monk, who was no other than the Shampooer of the II Act. It closes with his rescuing Vasantasenā, and placing her in a monastery in the charge of a Buddhist nun. And in the last (Act X), we have the important fact that Cārudatta appoints Śarvilaka as the Head of all the Buddhist monasteries (*viḥāra*) in the land (*prthivyām sarve-viḥāreṣu kulapati-ayam kriyātām*). It may appear on a superficial observation of the drama that there is no need for taking seriously all these details about the Buddhists, since in more than one context they are held in ridicule. For instance, a Buddhist monk is classed with the courtesans, an elephant, a Kāyastha, a cheat, and an ass. (Act V). And later on (Act VIII) he is held in contempt by the king's Brother-in-law (Samsthānaka). But it was not only the Buddhists who came in for a good bit of sarcasm on the part of the author. The Brahmans and those learned in the sacred law received the same treatment from the impartial royal dramatist. Thus, in one context Mai-

²⁰ See *Ep. Car.*, IV, Kl. 78 of the 26th year of his reign. Since this record is dated in A. D. 751, it is clear that A. D. 726 was the first regnal year of king Śrīpuruṣa II. His 42nd regnal year was A. D. 767. *Ep. Car.*, IV, Mb. 80. See also Rice, *Mysore and Coorg*, p. 50. The Ganga chronology, it must be admitted, is still a knotty problem; and the last word on some of the reigns has not been said. The reader's attention is drawn to my paper entitled *The Banas, the Gangas, the Kadambas*, etc. contributed to the III volume of the Modern History Congress Series, referred to elsewhere in this treatise.

treya is called a naughty priestling (*duṣṭa-baṭuka*). Even the learned judge reviles the poor Maitreya with the same undeserved epithet (Act IX) ! It cannot, therefore, be maintained on the strength of these remarks that the Brahmans and the Buddhists were held in low esteem in those days. On the other hand, the details about the Buddhists point to the high position they occupied in the country. Thus, we have the fact that the Buddhist monk, in spite of his being repugnant to the king's Brother-in-law, is permitted to wash his coloured garments in a well in the royal park (Act VIII). And there are the two facts of the Buddhist nun and the high administrative official of all Buddhist monasteries mentioned above.

Historical records enable us to find out the age when Buddhism was in a most flourishing condition in the Deccan. Before we proceed to cite the historical evidence in regard to this question, we may bear in mind that we have assigned king Śivamāra, who was no other than Śūdraka, to the second half of the seventh and the first half of the eighth century. The seventh century was precisely the age when Buddhism was at its zenith in the Deccan. Without citing the evidence of the many records which deal with Buddhism in the Deccan from the first century A. D. onwards till the middle ages, we may merely mention that Buddhism, which had first been introduced in the South in the days of the great Emperor Aśoka, made itself felt gradually all over the country until in the seventh century, it rose to unrivalled splendour in the land. It was in this century that the Tārā cult of the Mahāyāna School of Buddhism established itself in the land, and that the Buddhist monasteries came to be dotted all over the country.⁸⁰ Some of the most famous of these monasteries, now called Caves, in the Deccan, rose into prominence in this century. Thus, for instance, the famous manasteries of Ājīṇṭha (modern Ajantha), Karle, Junnar, and Nāsik, to mention only a few out of the many Buddhist centres, became so famous as to attract the attention of foreign witnesses.

One such foreign witness, who has given us an admirable account of the condition of Buddhism in the Deccan in the seventh century, is Yuan Chwang, the famous Chinese traveller, who sojourned in India between the years A. D. 629 and 645. In his detailed account of the Deccan, a large part of which was under the Western Cālukyas—who were repeatedly the suzerains of the Gangas—, we have enough proof to show that the land was, indeed, as the *Mk.* asserts, covered with Buddhist monasteries. While describing Mo-ho-o-t'ie-ch'a (Mahārāṣṭra), ruled over by the king Pu-lo-ki-she (Pulikeśin II), of the Western Cālukyan House, the great Chinese traveller writes thus : "There are about 100 *saṅghārāmas*, with 5,000 or so priests. They practise both the Great and the Small Vehicles (*i.e.*, the Mahayāna and the Hinayāna). There are about 100 Deva temples, in which very many heretics of different persuasions dwell. Within and without the capital are five *stūpas* to mark the spots where the five past Buddhas walked and sat. They were built by Aśoka Rāja. There are, besides these, other *stūpas*, made of brick or stone, so many that it would be difficult to name them all." Yuan Chwang then describes the famous Buddhist centre of Ājanṭha which, both according to him as well as according to an inscription found in Cave

⁸⁰ I do not wish to discuss this interesting question here.

No. XXVI in Ajantha itself, was built by the ascetic named Sthāvira Acala, whom the Chinese traveller calls Arhat Ācāra. Fleet, who has commented on this last part of the detailed description of Yuan Chwang, identified the other great *vihāra* mentioned by the Chinese traveller, viz., that at Nasik, which boasts of the Pāṇḍulena group of caves.⁸¹ The enormous mass of evidence dealing with Buddhism in the Deccan would furnish materials for a separate dissertation by itself. It is sufficient for our purpose to remark that the testimony of the Chinese traveller is more than enough to prove that in the seventh century A. D., Buddhism was certainly in a most prosperous condition in the Deccan.

(C) SOCIAL CONDITION

Turning to the social conditions as depicted in the *Mk.* we find that they amply corroborate our statement that the author of the first half of the *Mk.* was a native of the Deccan. We may analyse this part of our study under the following heads : food, sections of the people, miscellaneous items, and, finally, geographical data. Concerning food, we find that there is continual reference in the drama to the main food of the southern people. This is rice which is mentioned on many occasions. In the prologue we have the *Sūtradhāra* himself referring to the long streams of rice-whitened water flowing down the streets from his house. The same character asks the question whether he is hungry enough to think the whole world being made of rice. His wife assures him, in reply to another query, that she has sweetened rice, ghee curds, and ordinary rice ready for consumption. The *Sūtradhāra* again refers to rice spent by his wife, while chiding her. Among the things which, according to the villainous Samsthānaka, never lose their freshness is rice which has been cooked on a winter night. (Act I). Karpapūraka, the elephant-driver of Vasantasenā, while relating the story of the rogue elephant called Post-breaker, says that he himself, who had been nourished on the rice-cakes (lit. rice balls, *anna-piṇḍa*), obviously supplied by his mistress, took swift strides to bring the mischievous animal under control (Act II). In the fifth court-yard of the palatial residence of Vasantasenā, the Brahman Maitreya saw many interesting things, among which were crows which, even when tempted with rice curdled with milk, would not eat the offerings, because of its colour being exactly that of mortar.⁸² In the same Act IV. we have the statement of Maitreya that elephant-keepers are coaxing an elephant to accept a ball of rice from which oil is dripping. One of the scenes in the seventh court-yard of the beautiful residence of Vasantasenā, is that of a parrot in a cage, which like a Brahman with his belly well-lined with rice and curdled milk, was reciting a Vedic hymn. When Sthāvaraka confesses to the executioners in the last Act (X) that he himself was responsible for taking Vasantasenā to the royal park, the heartless Samsthānaka cries out in glee—"I have dined in my own house today off rice together with meat spiced with chilly powder and tamarind, with vegetables and fish curry, and with *śālī* rice and sweetened rice." The intimate know-

⁸¹ Fleet, *Dynasties of the Kanarese Dynasties*, pp. 354-355. Read Yuan Chwang in *Watters*, which is not available to me while writing this paper.

⁸² This is a direct reference to a wide-spread and ancient belief among the Southerners, relating to the oblations offered, for instance, on the anniversary of the dead (*Śrāddha*). If the crows will not eat the offerings, it is looked upon as an ill-omen; if the crows will eat them at once, it is supposed that the manes are satisfied.

ledge of the author of the *Mk.* of this important food in the South, is further shown in a beautiful comparison which no one who has seen the lovely southern tracts at the end of the monsoons, can fail to admire. While Cārudatta and Vasantasenā are bowing to each other, Maitreya remarks that they are meeting each other, like two rice crops, with their heads (Act I)!

If the above details about rice are insufficient to prove that the author of the *Mk.* was a Southerner, we may give another proof relating to another grain, which scholars have failed to identify till now. The vile Sams-thānaka rebukes the Buddhist monk, who has come to wash his clothes in the well in the royal park, saying that the latter should not wash in that place his coloured clothes which have a strong smell, their colour being that of the porridge of old *kulītha* beans (Act VIII). This word stands for a cereal which is still held in much esteem as food by the western and southern people. It is called *kulītha* and is commonly known as "horse-gram." No Northerner could ever have known the use of this grain as food.

The references to specified sections of the people afford another proof to maintain that the author of the *Mk.* was a Southerner. Candanaka upbraids Viraka, who is talking of distrust, and confesses that he himself is not a native of the Deccan. This passage where these details occur deserves a minute examination. "We Southerners are of indistinct speech (*vayam dakṣiṇātya avyakta-bhāṣiṇaḥ*). We know many dialects of the barbarians like the Khasas, the Khattis, the Kaḍas, the Karnātas, the Karnapravarnas, the Drāvidas, the Coḷas, the Cīnas, the Barbaras, the Kheras, the Khānas, the Mukhas, the Madhūgatas, and all the rest of them. We speak just as we like using the masculine for the feminine. Are we discussing rules of grammar? A discourse on the genders would certainly be irrelevant to the issue." (Act VI).

The above passage deserves a more detailed study than that which has been accorded to it by scholars. We could simplify matters by saying that it refers to the Southerners, who were supposed by some to have been proverbially given to ungrammatical speech.³⁸ But this does not solve the difficulty. When Candanaka confesses that he belonged to a section of the people who did not speak plainly, we have to conclude that it was not the Southerners—by which terms some modern scholars have come to mean the Dravidians—who were of indistinct speech, but the people to whom Candanaka himself belonged, who were given to *avyakta-bhāṣaṇa*. Indeed, the explicit mention of the Karnātas, the Coḷas, and the Dravidas, proves that these latter could never have been included among the people who spoke indistinct speech. It could never be said of the cultured and ancient Karnātakas, nor of the equally cultured and ancient Tamilians, that they ever spoke either indistinctly or ungrammatically, since they, specially the former, possessed a grammar which is just as perfect as that of the Aryans. There is no justification for modern scholars, who seem to base their remarks on a few statements of some older writers, to single out the Southerners as people of an inarticulate or indistinct or ungrammatical speech. We would argue the other way: since Candanaka admits that he belonged to a section of the people of the South, who could not speak plainly,—

³⁸ Cf. V. G. Paranjpe, *Introduction to Mk.*, p. XXII (1937 ed.).

although they knew quite a number of dialects.—we have to assume that he referred to his own community which talked some kinds of Prakrit, but which, evidently because of its recent emigration into the land, was not yet naturalized to have learnt the Indian languages quite well, or to have been acquainted with the nature of the different sections of the people mentioned by that character. Indeed, when Candanaka couples the ancient Coḷas, Karnāṭakas, and the Drāviḍas in general with the Mlecchas or the barbarians like the Barbaras, and others, he commits one of the grossest historical heresies ! For by no stretch of imagination can we ever group these cultured and ancient Dravidians with the barbarians mentioned above ! The only reason, it may be assumed, which prompted Candanaka to jumble together famous people, who were ancient and civilized, with uncultured barbarians, whose nature and habitat, as we shall presently see, were well-known to the rest of the people, was perhaps the fact that Candanaka himself belonged to a community which was new to the land. We do not know whether we could refer his community to that which centuries later would make Marathi its mother tongue. At any rate there is valid ground for assuming that Candanaka's confounding of the ancient Dravidians with the barbarians is just typical of those sections of the people, who even in our own days have failed to distinguish a Mysorean from a Tamilian.

Analysing further the above passage attributed to Candanaka, we may observe that some of the tribes mentioned by him have figured in history. For instance, the Khasas are an ancient people who are represented by the modern Khakkas. We have shown elsewhere that they sided with the Pāṇḍavas, along with some other tribes like the Tuṣaras, etc., in the memorable battle mentioned in the *Mahābhārata*; that an army of the Mlecchas, among whom the Khasas figure, routed the soldiers of Viśvāmatira ; that in the drama called *Mudrārākṣasa*, written by Viśakhadatta, they are described as forming a contingent marching side by side with the Śabarās to battle; and that in the *Mārkaṇḍeya Purāṇa*, the people called Ekapāḍas are placed after the Amadārakas and before the Khasas.³⁴ In Kalhaṇa's time they occupied the Pīr Pāntāl Range which forms the southern and south-eastern boundary of Kashmir. In the twelfth century one of their chiefs occupied the fortress of Bāṇāśāla in the same region. Their semi-independent principality of Karnāṭha (modern Karnāv) lay north of Dvārāvātī in the lower valley of the Kṛṣṇā (modern Kisen Ganga). In the first quarter of the fourteenth century, they invaded along with the Magars, the country of Nepal. The effect of their invasion of Nepal was so great that for quite a long time that country lay paralysed.³⁵

Their earliest sojourn to the Deccan is still a matter of speculation. But from historical records we are able to gather the following details about the Khasas in the Deccan from the twelfth century onwards. One of the earliest references to the Khasas in the history of the Deccan in a record dated A. D. 1130, in which the celebrated Hoysala king Viṣṇuvardhana Deva is said to have terrified Khasa.³⁶ That this victory over a Khasa ruler which was won by king Viṣṇu was a fact is proved by a later record dated A. D. 1190 in which he is credited with a victory over

³⁴ Read Saletore, *The Wild Tribes in Indian History*, pp. 32, 39, 48, 125.

³⁵ Ray, *Dynastic History of Northern India*, I, pp. 215 ff.

³⁶ *Ep. Car.*, VI, Cm. 139.

Khasa, Barbara, Oddaha, and other kings, who are named.³⁷ In A. D. 1068 the Western Cālukya monarch Āhavamalla (Someśvara II), is said to have levied tribute from many worthless kings, after slaying Khasa, Ābhira, Lāla, and rulers of other countries.³⁸ The Kaṭacuriya king Rāyamurāri Soyī Deva, also called merely Somarājendra, is said in a record dated A. D. 1174, to have split up Khasa, and destroyed other rules (who are named.)³⁹ One of the most well-known of the Ucchangi rulers was Vīra Pāṇḍya Deva, who in a record dated A. D. 1148 is said to have made the Khasa king, along with many others (named), tremble by his valour.⁴⁰

While the above evidence is enough to prove the existence of the Khasas as a people in the epic days, and as a sort of a power from the twelfth to the fourteenth century, it does not help us to solve the question which faces us—*viz.*, how the Khasas came to be included in the list of barbarians in the Deccan in the seventh century, when king Śūdraka, Śivamāra, wrote the *Mk.* We could, no doubt, tide over this difficulty by saying that this reference to the Khasas in the play is the earliest we have of the Khasas in the history of the Deccan. Their inclusion in the *Mk.* merely shows that in the seventh century, when the first half of the play came to be written, they had attained sufficient prominence to have attracted the attention of the author of the *Mk.* From the writings of western geographers and travellers, we know that the people of the Deccan were very enterprising, and that they had commercial dealings with many parts of the civilized world. It is not surprising that in the course of their commercial life, the people of the Deccan came across the Khasas, who were first attracted to the north; and that gradually the Khasas came to be included in the writing of a Southern author.

The same considerations hold good of the Khattis, who are mentioned next to the Khasas in the passage cited above. The Khattis were obviously no other than the Kaṭis or the Khattis, who have given the name Kāthiawar to the north-western region of Gujarat. They were once identified by Cunningham with the Kathoi of Sangala, who had opposed Alexander the Great. They are said to resemble the Gakkars in physique and habits.⁴¹

The next people called Kadas mentioned in the *Mk.* cannot be identified. We do not know whether the word Kada is an error of the scribe for Katār, which latter people have been identified with a wild tribe known to classical literature by the name of Cidaritae, a people of Chinese origin akin to the Yuchi.⁴²

The fourth people in the same passage are called either Kadatthobilas or Kadokadathovilas.⁴³ It cannot be made out whether they are to be identified with the Khatkaris of the modern times. These Khatkaris are a wild tribe inhabiting the Deccan, who along with the Bhils came in for some exemplary punishment in 1810 at Chauk, and who by 1818 came to acknowledge the authority of the British.⁴⁴

³⁷ *Ep. Car.*, V, Cn. 179.

³⁸ *Ibid.*, VII, Sk. 136.

³⁹ *Ibid.*, VII, Sk. 236.

⁴⁰ *Ibid.*, XI, Dg. 41.

⁴¹ Cunningham, *Archaeological Survey of India*, II, Pl. 33.

⁴² Cunningham, *ibid.*, Pl. 79.

⁴³ Ryder, *Mk.*, p. 102; Paranjpe, p. 108.

⁴⁴ Nairne, *History of the Konkan*, pp. 113, 125 (*Bombay Gazetteer*).

The Karnapravarnas, as we have elsewhere shown, are usually classed with the Lambakarnas and the Ekapādas in Indian literature. They were called by that name because they wrapped themselves in their long cars. They have been indentified with Enātoitai described by Megasthenes, as a people who had ears hanging down to their feet so that they sleep upon them. That they were known to the people of the epic times is proved by their inclusion in the *Mahābhārata*, among those who waited upon Yuddhiṣṭhira in his audience hall. Since they are classed with the Vangas or the people of Bengal and with the Kalingas or the people of Orissa, we have to assume that they inhabited the eastern provinces of India. But like the other wild tribes, they wandered to the south even in the days of the *Mahābhārata*. This explains why they are mentioned in that epic as living on the western coast, along with the Niśādas and the Kālāmukhas. The Karnapravarnas were also known to the Chinese as Tanerh or "Drooping Ears." Their wanderings finally led them to Indo-China, where they are called variously by the names of Li or Le or Loi, because of their ears reaching down their shoulders.⁴⁵

The Barbaras are likewise mentioned in the *Mahābhārata*, along with the Śabaras and the Kīrātas. They are located in the same work in the east and in the north. But the author of the *Harivaṃśa* would place them in the Vindhya.⁴⁶

We do not know whether the people called Kharas were identical with the Kharaparikas, who are mentioned in the Allahabad Pillar inscription of the great Samudra Gupta as having paid tribute to him.⁴⁷ Their name bears resemblance to that of the modern Kharpūras, who in the first half of the thirteenth century assisted Vāgbhaṭa to capture Ranthamhor from the hands of the Muslims. It is not unlikely that ethnologically the Khakars (or Gakkars), a Moghul tribe, may have been in some manner related to the Kharaparikas.⁴⁸

The Khānas, the Mukhas, and the Madhūgatas are not identifiable with the historical data available to us. Perhaps the Khānas were either Persians or the Arabs, although the latter hardly figure in the seventh century in the Deccan. And when they do appear on the scene they are called Tājikas in the records.⁴⁹

Of the remaining people the Cīnas were undoubtedly the ancient people of China, who by the seventh century had intimate trade relations with the people of the Deccan. And the Karnātas, the Coḷas, and the Drāviḍas, as already narrated above, were the most ancient and cultured sections of the Dravidian people. Of these we may select the Karnātas, who were, no doubt, the same as the modern Kannadigas. Two characteristics of these people deserve notice. These refer to their sense of loyalty and their warlike nature. On the road two high officials on duty are seen conversing with each other in the drama. One of them was called Viraka, who was General in charge of the Civil Administration (*tantrilaḥ senāpatiḥ, rājyaḥ pratyayitaḥ*); and the other was named

⁴⁵ Salletore, *Wild Tribes*, pp. 120-124.

⁴⁶ Salletore, *ibid.*, pp. 14, 17, 29, 33.

⁴⁷ Fleet, *Gupta Inscriptions*, p. 8.

⁴⁸ Ray, *op. cit.*, I, p. 1095.

⁴⁹ Fleet, *Dynasties of the Kanarese Districts*, p. 311.

Candanaka, Commander of the King's Forces (*rājāṇaḥ pratyayitāḥ balapatiḥ*). While discussing the desirability of inspecting the carriage (which contained Āryaka) on the road, General Viraka, who is charged by Candanaka with the grave fault of not knowing Cārudatta and Vasantasenā, retorts in a most admirable manner, thus :—"Friend, Candanaka, I know Cārudatta and I know Vasantasenā well. But when my duty to my king is concerned, I do not know even my father (*prāpte ca rājakārye pitam-āpi-aham-na-jānāmi*) !" (Act VI). That Viraka did not belong to the community to which Candanaka belonged is evident when we note that the latter has a different sense of duty. When the shivering Āryaka, whom Candanaka has discovered in the carriage, begs for protection at the hands of Candanaka, the latter replies :—"He is innocent and seeks my protection. He came in the cart of the noble Cārudatta. He is the friend of the noble Śarvilaka, who saved my life. On the other hand, there is my duty to the king. Now in the circumstances, what would be the proper thing to do? Or rather, come what may, I have already promised him my protection . . ." (Act. VI). We certainly admire the honesty and determination of Candanaka; but his views on the duty to the king were undoubtedly different to those of General Viraka. We may remember in this connection the assumption we made above in regard to the probable community to which Candanaka might have belonged. But all the same by his long stay in the land, Candanaka had imbibed the liberal atmosphere of the Deccan; and he amply proves the truth of the remark of the Chinese traveller Yuan Chwang, who, while describing the people of the Deccan, wrote thus :—"If they are asked to help one in distress, they will forget themselves in their haste to render assistance . . . they do not kill a man down (a person who submits.)"⁵⁰

In another context we have another example of a courageous, obedient, and honest servant of the royal family. He was Sthāvaraka, the slave of Samsthānka. When compelled by his rascally royal master to kill the innocent Vasantasenā, Sthāvaraka has the temerity to say :—"Beat me, kill me, Master, I will not commit a sinful act." (Act VIII).

The above examples demonstrate the high sense of duty and impartiality which characterized the people of the Deccan in the seventh century. Their idea of duty and justice is corroborated by many contemporary records, one of which we have cited above. This is the Hire Madhure *viragal* which records the death of the brave Bhānu Dāsa, the servant (*ālu*) of Konguniarasar (Śivamāra I). As already noticed above, Bhānu Dāsa is styled "A Champion of Victory" (*jayamitram*), Deluder of the Disloyal (*ūnara-vaiśikan*), one who obeys one's elder brother (*Anṇana-vatigan*), and one who does not fear the God of Death, Yama, (*Antakanga-añjadan*).⁵¹ Another brave soldier who died in another battle, by name Śrī Dāsiyamman, and who killed eleven warriors before he himself was killed, is described thus in another *viragal* :—"That his greatness pervaded all parts of the world . . . he died seeing that every one who is born is certain to die (*bhūtaḥ adol elliṃṃ sva-unnate puḡe jātasya maraṇam dhruvam emmeda . . .*)"⁵²

⁵⁰ Yuan Chwang cited in Fleet, *DKD op. cit.*

⁵¹ *M. A. R. for 1939*, p. 118.

⁵² *Ibid.*, p. 112.

Another characteristic of the Kannadigas is referred to by Candanaka, who thereby proves that he himself was not one of them. He says in the same context as that given above, *viz.*, while inspecting the carriage in which Āryaka was concealed, when taunted by General Viraka, who pointedly refers to Candanaka's enjoying the king's confidence,—“I shall employ the Karnāṭaka tactics of fighting (*Karnāṭaka-kalaha-prayogaṃ karomi*).”⁵³ As to what this *Karnāṭaka-kalaha-prayoga* was may be seen when we note what Yuan Chwang has got to say about the aggressive nature of the Kannadigas... “the disposition of the people is honest and simple; they are tall of stature, and of a stern, vindictive character. To their benefactors they are grateful; to their enemies relentless. If they are insulted, they will not risk their life to avenge themselves... If they are going to seek revenge, they first give their enemy warning; then, each being armed, they attack each other with lances (spears).”⁵⁴ Therefore, when Candanaka wants to imitate the Kannadigas he obviously wished to employ the above tactics referred to by Yuan Chwang, but without having either a spear or a lance in his hand, since such an act would have been derogatory to his high rank! But his sense of divided loyalty is in striking contrast to the dignified behaviour of General Viraka who, even when knocked down by his incivil colleague, declines to be disloyal to his royal master.

(D) GEOGRAPHICAL DATA

The foregoing discussion of the details pertaining to the peoples mentioned in the *Mk.* and to some of their well-known characteristics, must have convinced the reader that the author of the drama could have been no other but a Southern himself, since he has given a minute attention to the chief features of the people, which a king of Ujjain, for example, would never have either known or appreciated. The royal author has further given us some geographical data, which we shall presently discuss, and which further prove that he was undoubtedly a native of the Deccan. These geographical data centre round the physical features of the Deccan. The first refers to the Vindhya. Karnapūraka, while recounting his own exploits concerning the rogue elephant of Vasantasenā, tells his mistress the following :—“Furiously striking that elephant which looked like a peak of the Vindhya mountain, I rescued the monk who stood between its tusks.”⁵⁵ The very next reference to Ujjain by Karnapūraka is a confession that the Southern royal author was not fully aware of the incongruity of coupling the Vindhya with Ujjain, which is in the heart of the Mālwa plateau! But this was inevitable in a Southerner to whom the Vindhya have always stood as the best of mountains, but who desired to confound his contemporaries as well as posterity by mentioning Ujjain along with that well-known mountain range.

⁵³ Ryder stretches the meaning of the sentence too much when he translates it thus—“I'll stir up a quarrel the way they do down in the Carnatic” (Ryder, *op. cit.*, p. 102). The “Carnatic” used here is misplaced; historically it has reference to the eastern coast of India; whereas Karnāṭaka refers to the western part of the country. Wilson was perfectly wrong when he wrote that the phrase means that the Kanarese were notorious for their grossly personal abuse. He renders the passage thus—“I must give my friend here a specimen of Carnatic eloquence” (*Theatre of the Hindus*, I, p. 114).

⁵⁴ Yuan Chwang, *op. cit.*

⁵⁵ Ryder's translation of the word into “great mountain” (Ryder, *op. cit.*, p. 41) is erroneous, inasmuch as the context explicitly says *hastimam Vindhya-sikharābham*.

Our contention that the royal author of the first part of the *Mk.* was essentially a Southerner is further corroborated by the explicit reference to another southern mountain range—the Sahyādrī. The first executioner makes up his mind to kill the noble Cārudatta, lifts his sword, but finds to utter astonishment that it drops from his hands ! He at once prays to his goddess, thus :—“Please, please, Venerable goddess of the Sahyā ! Is it possible for Cārudatta’s life to be spared ? (*Bhagavatī-Sahyavāsini prasīda prasīda api nāma Cārudattasya mokṣo bhavet*) (Act X). The word *Bhagavatī*, we may incidentally note, is not to be understood merely as goddess, or a mighty goddess, but as an appellation of the Buddhist goddess Tārā, who, as we have already seen, was then (seventh century), universally known as Tārā Bhagavatī throughout the Deccan. This particular appellation of the goddess, it may be observed, corroborates the statements we have already made to the effect that Buddhism was in a prosperous condition in the Deccan in the seventh century.

There is another geographical detail which establishes beyond doubt the truth of the fact that the royal author of the *Mk.* was a southern monarch. On the execution ground, Cārudatta is rescued by his friend Śarvilaka, who informs him that he (Śarvilaka) has killed the wicked king Pālaka and reinstated the innocent Āryaka on the throne ; and that king Āryaka’s first act on ascending the throne of Ujjain was to confer a kingdom on Cārudatta as a gift. Modern commentators have variously given the rendering of the passage as the throne of Kuśāvati (situated) on the bank of the Veṇā. (Act X). The expression *Veṇātaṭe Kuśāvatyām, rājyam*, no doubt, admits of the interpretation given by scholars. It would mean that we have to suppose that the chief city of the kingdom was called Kuśāvati situated on the bank of the river called Veṇā. Our contention here is that the name Kuśāvati is typically southern ; that it refers to a river of that name on the western coast ; and that perhaps the reference here is to a kingdom that lay between the Kuśāvati and the Veṇā. If the author of the *Mk.* were a Northerner, he would never have known about these two small rivers of the Deccan. Some scholars have, no doubt, correctly maintained that the inclusion of the name Veṇā points to the southern origin of the author of the *Mk.*⁵⁶ That name refers to one of the tributaries of the Kṛṣṇā, which together with this tributary called Veṇā was called so early as the second century A.D. Kañṇavenna (Kṛṣṇavennā), is an inscription of king Khāravela.⁵⁷ The Veṇā is no other than the modern Yenṇā, which is one of the most important feeders of the Kṛṣṇā, and which meets the Kṛṣṇā at Sangam-Mahuḷi, three miles east of Sātāra.⁵⁸ As regards the other name Kuśāvati, it is also the name of another river, the exact location of which is given in a damaged record dated about A.D. 1570. This record is written in Nāgari characters, and it relates that the holy river Kuśāvati was in Āraga (*Āragada-Kuśāvati-tīrthada*). On the bank of this river lay the town of Sadāśivapura, the manager of which along with other Brahmans made specified gift in about A.D. 1570.⁵⁹ From epigraphic records we know that Āraga was the name of a very large province called by the famous name of Āraga Eighteen Kampana, and in the Vijayanagara days Āraga Rājya. It comprised the Male-rājya or the hill kingdom

⁵⁶ Cf. V. G. Paranjpe, *Mk.* P. I., Intr., p. XXII.

⁵⁷ *Epigraphia Indica*, XX, p. 87.

⁵⁸ *J. B. B. R. A. S.*, XII, p. 10.

⁵⁹ *Ep. Car.*, VIII, Tl. 18.

of the west. Āraga today is in the Tīrthahallī tāluka of the Shimoga district of the Mysore State.⁶⁰ If we accept the opinion of modern scholars that it was only a tiny thrope of Kuśāvati—which, however, sounds rather unintelligible!—, we have to suppose that the kingdom of Kuśāvati was somewhere near modern Sātāra. A small principality was hardly appropriate for such a large-hearted soul like Cārudatta, whose generosity was as extensive as the ocean itself! We have, therefore, to assume that it was a larger stretch of country which was conferred upon him by king Āryaka. Such a stretch would be the kingdom bounded by the Kuśāvati on the south and the Veṇā on the north. It would represent a large part of the modern Southern Maratha districts and a portion of the North Kanara and of the Shimoga district as well.

The above presupposes that the kingdom of Śūdraka, whom we have identified with the Ganga king Śivamāra I, extended over a large part of the modern Bombay Presidency, including certain portions of the Mysore State. This leads into a purely historical investigation of the extent of the Ganga kingdom in the seventh century A. D. We know from the epigraphs of the period that in the age of Durvinīta (first half of the sixth century), the whole of the ancient Punnāṭa (southern Mysore) and Pānnāḍ territories had passed under the suzerainty of the Gangas. In the reign of the same king Durvinīta, the Ganga arms extended as far as the Salem, Coimbatore, and even distant Chingleput districts in the south. With the capture of the Pallava king Kāduveṭṭi by king Durvinīta, the Ganga power was extended to Kañci (modern Conjeevaram) near Madras. In the reign of his son and successor Muskara or Mekkara, the Ganga kingdom was extended to Dharwar in the north. In the reign of his elder grandson Bhūvikrama, the Gangas again brought under their control the Pallavas whose great capital Kañci they conquered and occupied, as a result of the glorious victory which they won in the battle of Viḷinda, which we have referred to above. We may be permitted to repeat that it was perhaps in this battle of Viḷinda that king Bhūvikrama's younger brother, the future Śivamāra I might have lost one of his eyes. King Śivamāra I's wide sway was cast over the Torenāḍ 100, the Kongalnāḍ 1000, and the extensive Malenāḍ, which last was precisely the Male-rājya which in later years boasted of the famous Āraga Eighteen Kampana province with Āraga itself as its capital. When, therefore, a reference to Kuśāvati is made in the *Mk.*, we have to note that it was a river within the jurisdiction of the wide kingdom of king Śivamāra I. Turning to the northern parts of the kingdom of the Gangas, we find that in the same seventh century, and in the first half of the eighth century, the Ganga kingdom comprised the Sindavāḍi province which was made up of the Bellary, Bijapur, and Dharwar districts. We may remember here that the main line of the Sindas hailed from Karahāṭaka (modern Karhād) in the Sātāra district, where precisely the river Veṇā flows. That this extension of the Ganga influence was far reaching to the north, certainly as far and beyond the limits of the Sātāra district, is proved by a later record dated A. D. 1077, which informs us that the Ganga kingdom extended as far as the Tāvi.⁶¹ The river Tāpi or

⁶⁰ For further details, See Saletore, *Social and Political Life in the Vijayanagara Empire*, I, p. 298, and q. v.

⁶¹ Rice, *Mysore and Coorg*, pp. 35, 36, 37, 38, 147; *Ep. Car.*, VI, Mg. 36; VIII, Nr. 35.

Tāvi, or Tapti was the southern boundary of the province of Lāṭa or southern Gujarat.⁶² If the evidence of this later record may be accepted in order to substantiate the statement of an earlier event, then, we may maintain that the gift of a kingdom which was within the limits of the rivers Veṇā and the Kuśāvati, as given in the *Mk.* is intelligible, since it was a province that lay within the limits of the Ganga kingdom, whose ruler we have identified with king Śūdraka of the *Mk.* The rivers Veṇā and Kuśāvati were essentially southern rivers ; and the geographical details, therefore, as given in the *Mk.* point unmistakably to the author's having been a Southerner, who was well acquainted with the physical features of his wide kingdom.

(To be continued)

⁶² Bhandarkar, *History of the Early Deccan* (in *Bom. Gaz.*), pp. 199.

A NOTE ON MR. GODE'S ARTICLE ON THE HISTORY OF THE JAṬĀŚAMKARA TEMPLE AT NANDURBAR

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IN the July (1946) Number of this *Journal* while giving the history of the Jatashankar Temple at Nandurbar Mr. P. K. Gode has once more emphasised his opinion, which he had already expressed in the *Annals of the Bhandarkar Oriental Research Institute* (Vol. XVI, Parts III and IV), that the King Sambhaji Chhatrapati was the patron of the poet Hari Kavi alias Bhanu Bhatta of Surat and that the poet had composed a poem Shambhuraj-Charita in honour of the same king.

A critical study of both the articles led me to think that Mr. Gode's conclusions are not sound and in the light of some evidences available regarding the local history of Khandesh I can safely say that those conclusions could never be acceptable.

The extracts given by Mr. Gode from the work of the poet clearly connect the patron Shambhu and his father Shiva with Nandurbar the town that is praised best in the poem. The stanza No. 22 runs as follows:—

“पुरं नंदिद्वारं निखिल गुणसारं त्रिजगति
सुखानामाधारं भुवनवलये संविलसति ।
यदस्मिज्जायन्ते सकल जन सतुष्ट मनसां
जनानामानंदाः किल सुमनसां मोहनकराः ॥ २२ ॥

The first word पुरम् of this stanza is identical with the one in the sentence when the poet himself as the commentator commences to comment on the subject of describing the residential town of the hero.

अथ स्वसंभावनाकरमेत त्काव्यकरणहेतुभूतशंभुनामक राजविशेषं
श्रावयस्तन्नगरादिकं वर्णयति पुरमिति

This is still more emphasized in the stanzas that follow. After the description and praise of the town there is the stanza given to the praise of the presiding deity Jatashankar of the place. Then the verse that follows praises one “Shiva” whom Mr. Gode wrongly takes to be Shivaji the Great. Here is the verse:—

इहासीन्नासीरं रुचिरतनुभाजां त्रिभुवने
शिवाख्यो देशानामधिपतिरनेकाद्भुतगुणः ।
यमालोक्योत्फुल्लद्विपुलनयनोद्गीर्णनिमिषाः
समुत्तीर्णा भित्ताविव समभवन्सर्ववनिताः ॥ २४ ॥

The opening words इहासीन् clearly connect this Shiva with Nandurbar and the stanza that comes after, gives the parentage of the hero saying “of this Shiva that Shambhoo was born”. The stanza runs as follows:—

प्रदीपो दीपांगादिव गगनरत्नादिव महा-
महः पुंजा : पद्मादिव परमसौरभ्यनिबहः ॥
सुधाशुक्षीराब्धेर्विव हरितरुर्नर्दनवना- ।
दिवायं संभूतः किल शिवनृपाच्छंभुनृपतिः ॥ २९ ॥

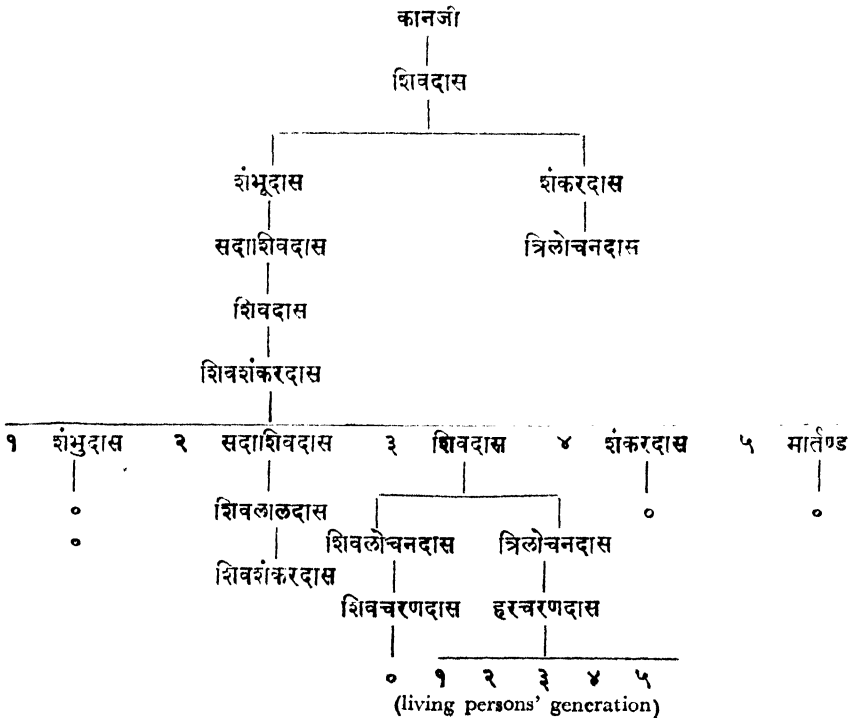
Mr. Gode has taken this pair of Shiva and Shambu from the poem of Harikavi to be none other than that of Shivaji and Sambhaji. Nandurbar never formed the part of the kingdom of the Chatrapatis under Shivaji and Sambhaji. It was attacked and ransacked by them on occasions more than once but that does not entitle them to be called the kings of that town. If that flimzy connection between the famous kings and the town is accepted to justify their being called kings of that town it would be equally applicable in case of Surat also which the learned author of the poem does not seem to have done.

I produce here an extract from an inscription in the temple of Ashapuri Devi at Patan near Sindkheda in the same district.

आशापुरीसकल कामपुरी जनानां
तस्यानिकेतनमिदं अथ मंडपश्च ॥
नंदावतिस्थ शिवशंकरदासनाम्ना
देशाधिपेनरचितः खलु देविप्रीत्यैः ॥ १ ॥

संवत् १७४४ प्लवंगनाम संवत्सरे आषाढ शु. १० भागुवार.

The inscription shows that there was one Shiv Shankardas Desai of Nandurbar who was a contemporary of Sambhaji, as the date mentioned in this inscription is Samvat 1844 corresponding to 1687 A. D. Below is produced a geneological table of the family of Desais



A word or two about the history of the family will not be out of place here. The Desais of Nandurbar were the Sir-Kanugos and Sardesai of Nandurbar Sirkar. This division comprised of more than one-third part of the present West Khandesh District. By the British they were deprived of their hereditary offices and were given in lieu of that, some cash allowance and Jahgir of two villages which is still continued.

In the table mentioned above we have two cases of the pairs of the father and son being called Shiva and Sambhu respectively. Out of these pairs the one implied in Hari Kavi's poem seems to be identical with the second pair because the inscription of Patan mentions Shiva Shankardas and the date also agrees with the date available from the works of Harikavi.

It is needless to try to show in detail that many of the conclusions based on the above said principle conclusions of Mr. Gode are wrong and they can be explained otherwise. As for example, the poet himself calls दक्षिणात्य. The deliberate mention of the poet that he is a Deccani Brahmin only fits in the Gujarathi environment in which he had to flourish. Had he been a Court Poet of the Chhatrapatis there was no propriety in mentioning his being a Deccani Brahmin.

The Desais come from Dasa Porwad caste of Gujarat. The tradition says that they have changed their faith from Jainism to Shaivism and then to Vaishnavism which cult they at present follow. But the Shaiva element is still apparent in the nomenclature of their family. The architecture of the Jatashankar temple and that of the temple at Patan belong to the same age and type. The bull from the Jatashankar temple seems to have been of greater antiquity than the structure of the temple and it is possible that somebody from this family might have built that temple also.

THE PAPER INDUSTRY IN INDIA

By B. G. TALATI (M. COM. CLASS)

THE paper industry is to-day one of the major industries of India. India was known for hand-made paper long ago, but production of machine-made paper was not until 1870, when the Bally Paper Mill was started on the Hooghly. Some years after in 1882, the Titaghur Paper Mill was established under Non-Indian management which took over in 1903 the Imperial Paper Mill and by 1913 produced annually 20,000 tons with 8 machines. During the same period, the Upper India Couper Mill established in 1879 raised its production capacity to 4,000 tons annually; the Deccan Paper Mill, Poona, started in 1887 could maintain its production to 1,700 tons annually; the Ranighang Paper Mill started in 1891 increased its production to 8,400 tons annually. There were 3 other small mills also. The industry had to overcome many handicaps in the beginning as it was a new enterprise of high technique. It lagged behind in development in respect of establishments, employment, and production to those of the Cotton Textile and Sugar industries which were already established at that time. At the time of the outbreak of the first world war in 1913-14 annual production and consumption were 28,700 tons by 9 mills and 83,000 tons respectively.

The progress of the industry during the first world war, in respect of workers employed, production and imports will be seen from the following :

Year	No. of Mills	Workers Employed	Production : Q. Tons	Imports excluding Writing Paper and Envelopes : Q. Tons
1914	9	4,565	28,700	71,390
1915	9	4,665	30,400	48,485
1916	8	5,015	31,900	39,325
1917	8	5,180	31,400	16,700
1918	8	5,410	30,000	
1919	7	5,790		

In 1914, the first year of war, production was 28,700 tons and 30,400 tons in 1915 and 31,900 tons the maximum in 1916. Imports in 1914 were 71,390 tons and fell to 48,485 tons and further to 39,325 tons in the next two years, the minimum being 16,700 tons in 1917. It did not increase in the same magnitude as imports decreased. It was far less in inverse ratio than imports. Number of workers steadily increased from 4,565 in 1915 to 5,410 in 1917 when 8 instead of 9 mills were working, and to 5,790 in 1919 with 7 mills working. The progress during the first war was far reaching in character that it was considered as one of the major and important industry.

The progress of the industry during the second war also is very speedy yet substantial. Following figures will show number of mills, workers employed, production and imports during the war period.

Year	No. of Mills	No. of Workers	Year	Production : Q. Tons	Imports : Q. Tons
1939	12	11,910	1939	70,810	167,650
1942	16	15,280	1940	87,660	135,050
1945	16	17,630	1941	93,550	105,150
			1942	91,040	65,400
			1943	100,280	19,480
			1944	99,830	33,555

Production increased from 70,810 tons in 1939 to 93,550 tons in 1941 and to 100,280 tons in 1943, the peak level during the War. In 1942 it receded temporarily as mills were closed on account of coal shortage. Imports decreased in 1939 and in subsequent years from 1,67,650 tons in 1939 to 1,05,150 tons in 1941 and dropped heavily to 19,400 tons in 1943, the lowest for the first time. Number of mills increased from 12 to 16 and workers employed increased from 11,910 in 1939 to 15,280 in 1942 to 17,630 in 1945. The development was substantial both in production and employment than the first war.

Industrial activity was in high oscillation during the war than at any other time. Government requirements for defence and other multiple departments increased. Imports could be arranged only on multilateral transactions. Limited imports were channelised which came down appreciably. There was export of paper to the neighbouring Empire countries such as Burma, East Indies, Malaya, Ceylon, etc. Exports to Burma accounted for 2,240 tons in the year 1945 in exchange of rice. Raw materials could not be despatched at a proper time so as to keep pace with production which was very often interrupted by lack of adequate transport and raw materials. Government monopolised 80. p. c. to 90 p. c. of production capacity for their requirements. Only 10 p. c. of it was allotted for civilian use. This indiscriminate monopoly on the part of the Government accentuated the scarcity and shortage of paper on account of limited imports. In order that the limited supply of paper may be equitably distributed controls were put into operation. The supply was insufficient as compared to the demand that even under the strict supervision of Government, it could not be distributed equitably without sad results in the form of black market and corruption. Distribution system was lopsided and faulty that mills were ordered to supply far off market with high transport costs as delivery was f. o. r. destination and established customers in the nearer markets were kept starving. On account of acute coal shortage, mills were closed for some time in 1942 and production receded temporarily in that year. Introduction of 3 shift system and rationalisation brought about increase in production under stringent war conditions, and in 1943 it rose to 100,280 tons very nearer to its potential level of 1,10,000 tons. But the total consumption of paper during the war decreased irrespective of additional demands of war. The reduction in consumption of paper checked our industrial and educational activities.

War time industrial progress of a few major industries in India will be seen from the following figures of production.

Production Figures

Name of the Industry	1939 : Q. Tons	1940 : Q. Tons	1941 : Q. Tons	1942 : Q. Tons	1943 : Q. Tons	1944 : Q. Tons
Pig Iron	91,885	98,165	1,00,760	90,220	84,330	66,600
Cement	86,670	86,380	1,11,120	109,140	105,560	108,000
Paper	70,810	87,660	93,560	91,040	100,280	99,830
Jute	63,845	55,465	63,948	62,360	53,395	54,000

It is worth noting that the paper industry is only second to the Cement industry in recording continuous increase in production and in maintaining its production to that level through out the war. It stands to-day among the five major industries.

The financial stability of the industry can be judged from its capital investments and profits made which are as follows.

Profit Ratio Calculated on Chain Index Base—Year 1928

Year	No. of Companies	Profits : Rs. (000)	Profits of the Same Cos. in Preceding Year	Chain Index Base 1928 × 100
1928	3	—	—	100
1938	4	34,45	36,60	172.1 p. c.
1939	4	30,39	34,45	151.8 "
1940	8	71,72	30,35	358.7 "
1941	8	86,81	71,72	432.2 "
1942	8	97,64	86,81	438.4 "
1943	8	119,28	97,64	596.6 "

Increase in production during the war is less than double. Profits are 375% more than the pre-war level. Taking 1928 as the chain index base year, profit is 172% in 1938 first year of the war and 596% in 1943. The return on capital investment in this industry is comparatively high. There is sufficient temptation for capital to be subscribed by the public in this industry and as such there is no necessity of financing it with foreign capital. It is equally true that it will be efficiently managed if owned by private enterprise rather than owned and managed by the Government. Nationalisation of the industry will yield no benefits to anybody but heavy burden of supervision, control and management on the shoulder of Government. As exploitation of soft wood of the Punjab, Kashmir, Tehri Gerhwal, etc. on commercial basis is considered uneconomic on account of heavy works cost and high freight, Government should undertake on its own account in absence of private enterprise establishment of Newsprint industry which requires mechanical wood pulp for its manufacture. Monopoly both of finance and management of the vested interest put India into serious disadvantage and even to-day the higher and technical posts are occupied by non-Indians. It is an industry of high technique in

which scientific outlook and mechanical knowledge are essential, hence technical help from foreigners will be required for a few years temporarily, which can be easily arranged on terms of service agreement. The Research Institute at Dehra Dun will not only be a research station but a training centre where technical education will be imparted to Indians in the meantime.

Following are the figures of capital investments of India's major industries.

Value of Plant and Machinery in Different Industries in 1938-39

Name of the Industry	In Million Rs.
Cotton Textiles	546·374
Jute	315·863
Sugar	264·960
Iron & Steel	171·966
Electric Power	284·998
Cement	114·650
Paper	27·280

It is the last in regard to capital investment of all industries. Only Rs. 27,280 million are invested nevertheless it is highly capitalised and as such a high block account increases the overhead charges and the return required on capital is high. Besides renovation of plant and machinery out of war profits is only partial and insufficient as very low reserves are maintained. The works costs are certainly increased by old and antiquated machinery and high wear and tear during the war. The high capital and recurring costs with low depreciation and reserves result in high cost of production per unit which in turn put the industry on unstable and weak position as will be seen from the following :

Cost Per Unit Ton of Paper in 1923-24

	Titaghur Mill	Bengal Mill	India Paper Mill
Fixed Capital Costs	820	800	900
Cost of Materials, etc. Recurring Costs	541	519	461

Some Items of Overhead Costs

Office Expenses and M./A. Remuneration	Rs. 15/-
Interest on Working Capital	20/-
Depreciation	50/-
	<hr/> 85/- per ton

The capital cost per ton of paper is Rs. 800/- to Rs. 950/- which are high enough, and the interest on this capital is Rs. 20/-. Cost of raw materials is comparatively high because the more grass, bamboos

and coal are brought from far off distances, the more are freight charges incurred. The size of the industry is 6,000 tons per annum and is small as compared to foreign unit of 15,000 tons per annum. Large scale economies are counterbalanced by disadvantages of unstandardised products. Inefficient management adds its own incidence on cost of production. Indian paper lacks in quality and is of high cost to foreign paper made from wood pulp and rags. Moreover, sale methods of individual mills are competitive. Mills offer to retail dealers at wholesale prices in competition with their own dealers. Very often, high rates of discount and job lots of good quality are offered. Sale organisation maintained by these mills is very costly.

In the period after the last war, the industry was taxed by incidence of high costs on one side, and keen and cut throat competition on the other. Foreign Governments subsidised their industries which raised production level to the fullest capacity. Cost of production was reduced in foreign countries because of application of war time research to the industry. It was very difficult to sell goods in the home markets during depression. Dumping of paper took place in India as the foreign Governments maintained higher prices in home markets and lowered prices in the Indian market either by currency depreciation or actual reduction. The competition was so serious and cut throat to withstand without Government's assistance. The question of protection was referred to the Tariff Board for the first time in 1924. Government in accepting the recommendations discouraged imports of wood pulp and writing paper by levying heavy duties. In order that supply of bamboo pulp may be stimulated the India Paper and Pulp Co. Ltd. was subsidised to utilise bamboo as paper making material on a commercial scale by means of Wraitts Sulphate process. But ambiguities and prejudicial interpretations of the schedule added miseries and during the great depression, the industry was put to very precarious position. Government had to refer the question of protection and interpretation of the tariff schedule more than once.

The Boards on all occasions have ascertained that it satisfies all the 3 conditions of protection laid down by the Fiscal Commission. It has raw materials in abundance. The main raw materials are sabai grass bamboo besides old rags, linen, hemp, jute waste and imported wood pulp. Paper produced from grass is very tender, lacks in quality and comparatively of high costs. Bamboo as a paper making material is cheap and its products resemble in quality to the foreign paper. It is two to five years crop and its reproductivity is fast. It provides avenues of further developments which are closed to the industry so long as it is dependant on grass and foreign pulp. Besides it will preserve timber resources of the country for more important uses. Effects of recommendations will be seen from the following :

Raw Materials	1936-37—Tons	1944—Tons
Bamboo	19,281 pulp	1,87,000 pulp
Sabai Grass	11,510 ..	69,086 grass pulp
Waste Paper	5,908	17,400
Old Rags, Cloth Cuttings	8,868	27,328
Imported Wood Pulp	10,976	—

— . . . —

All mills practically use bamboo pulp for paper making. Production of bamboo pulp increased from 19,281 tons in 1938 to 1,87,000 tons in 1944. Increased use of grass, waste paper, rags cuttings, etc. are made for paper making as scarcity of bamboo is felt owing to its requirements for military purposes.

The auxiliary materials are soda ash, bleaching powder, caustic soda, chlorine, dyes, rosin, lime and clay. India is dependent on foreign countries from the beginning for these chemicals. A part of the requirements is met to-day by home industries. It will have to depend for some time on foreign countries for these chemicals. Following are the chemical requirements in 1951 and 1956 as anticipated on the basis of consumption in 1944.

Name of Chemicals	Actual Consumption in 1944 (Tons)	Anticipated Consumption in 1951 (Tons)	Anticipated Consumption in 1956 (Tons)
Soda Ash	6,359	16,000	30,000
Caustic Soda	9,073	10,600	18,400
Alum Ferric	8,376	12,600	22,600
Rosin	2,473	5,800	10,800
Salt	14,684	44,000	73,000
China Clay	4,873	30,000	47,300
Sulphur	3,524	5,200	8,800
Lime	3,524	92,000	160,000
Other Chemicals			
Total	110,000	230,000	394,000

Its chemical requirements are 230,000 tons and 3,94,000 tons in 1951 and 1956 respectively which is double and triple to that of consumption of 110,000 tons in 1944.

The manufacturing materials are coal, oil, fuel and electric power etc. Coal is sufficient in India to meet the requirements of the country. The quantity of coal consumed in 1944 is .345 million tons. On the basis of 3 to 5 tons of coal consumption per ton of paper .66 and 1.99 millions tons of coal will be consumed by the industry in 1951 and 1956 respectively. Some mills have reduced their coal requirements and are now working on oil or electric power. Cheap hydro electric power is merely a beginning in India. The high cost of production will be largely reduced if cheap power is made available. The future location of the industry will be selected at a point where both raw materials and cheap electric power under the grid system is available.

India is an importer of machinery from the beginning of machine made paper and to-day, it is virtually dependent on foreign machinery. It is assumed that Rs. 10 crores are the capital requirements of the industry. The Department of Capital Control Issue permitted during Dec. 1945 to June 1946, 12 companies with Rs. 4.32 crores capital to start paper and board mills. 11 companies with Rs. 3.79 crores of rupees and 1 company with Rs. 85 lacs will be started in the British India and Indian State respectively.

Selection of site in case of paper industry depends upon many factors at hand such as (1) availability of raw materials (2) cheap power (3) water supply (4) sufficient transport facilities (5) proximity to markets. It sprang up in the Bengal which is its home even to-day. Raw materials viz., sabai grass and bamboos are obtained from northern India and coal from Orissa coal mines. The port of Calcutta affords extra facilities in addition to the fact that the territory of Bengal is a wide market to the mills situated in that area unlike Shree Gopal Mills situated in far north of India, whose low cost are counterbalanced by high freight on finished products.

There are 16 paper mills in India which are distributed as under :

Bengal	4	U. P.	2	Mysore	1
Orissa	1	Punjab	1	Travancore	1
Behar	1	Madras	1		—
Bombay	3	Hyderabad	1		1

Undue concentration of industry is undesirable as much from the point of view of balanced and planned economic development as for strategical reasons. The future location of the industry should be conducted on regional basis for balanced economy. The principle of disintegration and decentralisation should be followed so that advantages of nearby market will be secured besides other inherent advantages of cheap labour etc. So long as soft wood as pulp making material is not exploited on commercial basis in India, pulp and paper making processes would be centralised at a single place unlike America or Canada where they are carried on as distinct and separate at different places and in different parts of the country.

It is a paradox in case of India that the more the population the less is the consumption of paper which is the life blood of civilization. Production and per capita consumption of paper of different countries are shown below :

Year	Country	Production in Tons (000)
1941	U. S. A.	18,630
1943	Canada	3,966
1943	India	100

per capita consumption of paper of different countries in 1937.

U. S. A.	..	..	..	..	..	..	241 Lbs. per annum
Great Britain	..	..	..	..	..	..	134 " " "
Denmark	..	..	..	..	..	..	96 " " "
Norway	..	..	..	..	..	..	94 " " "
India	..	..	..	..	..	..	1 " " "

India produced only 100 million tons while U. S. A. and Canada produced 18,630 and 3,966 tons respectively. Indian production is only $\frac{1}{2}$ per cent of the world's production in 1942 and India's population is $\frac{1}{5}$ of the world's population. It is very discouraging to note

that the per capita consumption of paper in India is only 1 lb. as compared to 241 lbs. of U. S. A. and 136 lbs. of Great Britain. If production is a barometer to know the economic development of the country, consumption of paper is an index to mark the progress of civilization. The more the country is civilized, the more is the consumption of paper. India has full scope to develop economically nevertheless the percentage of literacy is very small as seen from both production and per capita consumption figures of India and of different countries.

India with long stretches both in the East-West and North-South is undoubtedly a sufficient home market for the industry. Consumption of paper is bound to be high as the literacy campaign will be operated in the whole of India by our National Government—which has a plan to spend Rs. 3 crores a year on average for 20 years on education. Similarly provincial Governments have their separate plans of education—for the post-war period. It may be said that the development of the paper industry is directly connected with the literacy programme of the Government and their economic betterment. The Paper Panel has anticipated paper consumption of 2,800,000 tons and 4,220,000 tons in 1951 and 1956 respectively. There are chances of new paper mills to be established.

The problem of high costs can be solved by efficient management. What the industry requires is reorganisation and rationalisation which will reduce cost of production and bring increased efficiency. The existence of uneconomic and inefficient units is prejudicial to the sound development and may be removed by scientific and technical efficiency. The size of the unit should be raised from 6,000 tons to 8,000 tons to make it optimum so that minimum economies will be obtained. Standardisation of products is very essential and as far as possible uniform standards of different varieties should be maintained over the entire industry in the country. Production will be maximum on the machine best suited to its purpose by standardisation. Indian products are mainly writing paper and boards while kraft and newsprint are not at all produced in India which should be encouraged. The convertible paper industry will stimulate the demand for paper further if sufficient encouragement is given to the many uses of paper such as paper towels, cups, boxes, handkerchiefs, etc. The last but not the least important to keep it on its smooth road is to continue protection for a few years more as recommended by the Paper Panel. It has emerged from the war successfully. But the success seems to be transitory and it will receive setback if protection is discontinued. Because it is protected for 22 years protection should be discontinued is not sound argument. On the contrary, there is double necessity of protecting it in the aftermath of war. Foreign Governments have subsidised their industries. Sweden has depreciated its krona. Many invisible benefits in the form of low freight and insurance etc. given by foreign Governments to their industries are not present and are dangerous to our industries. If evil effect of cut throat competition and dumping as found in the period of depression after the last war, are to be mitigated protection should be continued and scientific research should be conducted in full co-operation with the mills by the state. Freight rates are not only reduced but are raised which as cripple the industrial structure, should be revised so as to facilitate shipments of goods in different parts of India both internally and

externally with the least additional cost of transport to the production cost. The industry should organise and extend its field of work to marketing and distribution. A Central Marketing Organisation on the lines of the Cement Marketing Association or similar to Indian Paper Sales Association, if started will help to retain the home and foreign markets captured during the war. The Government of India should facilitate the Paper Industry delegation in procuring new machinery with latest mechanism to replace the old worn out machinery and also to study in foreign countries the war time developments in the industry. The subsidiary industry of making spare parts and small tools should be encouraged.

Establishment of the Cellulose Research Institute is welcome. Its function should include research not only in chemical properties but in physical properties in which only the paper industry is interested. Cellulose is available in plenty in agricultural products and its waste besides forestry products. India will have sufficient pulp at a time when the world faces with pulp shortage. The Indian Paper and Pulp Committee with independent organisation and laboratory similar to the Imperial Sericultural Committee should be established by the Government to study and investigate the problems of the industry. It should include within its perview (1) annual review of paper and pulp manufactured in the whole of India. (2) future programme of development work (3) publication of the results of research work (4) exploitation of research on a commercial scale etc.

The paper industry in India with proper organisation and efficient management has a promising future.

INDIAN SONGS IN THEIR SOCIAL SETTING¹

BY MRS. S. KOTAK, M.A.

(CONCLUDED)

V SONGS PERTAINING TO GURU WORSHIP

THIS fifth group of songs touches the delicate question of Guru worship. Knowledge and art are handed down to a Hindu in pupillary succession. A Guru not only imparts his knowledge but also plays an important role in the formation of man's general character ; a good Guru is said to protect one from worldly sins and miseries, and also acts as a sure guide, enlightening one's path towards the attainment of the knowledge of Parabrahma.

Hence there are many a song composed to express the *Guru-mahimā*.² The following songs manifest the sentiment of devotion to one's Guru, in one way or another. Almost all of these songs are set in Tāla *Tritāla* ;³ rhythm in which they are generally sung is medium (*madhya*).

The following song makes an appeal to surrender one's self at the feet of one's Guru :

(63) *Rāgiṇī Sōhinī, Tritāl, Madhya Laya*
(Medium Rhythm)

(63) Translation

Sthāyi :

Guru charaṇa śaraṇa kara manujā,

A man must surrender himself at the feet of his guru,

Vifala hōta aṇamōla sakala vaya,
Gharī pala kabahū na pāchhi firata ;

This priceless life passes fruitlessly away,
Moments and seconds never return ;

Antarā :

Nānā tiratha Hararanga⁴ hai firata,

"One may visit several places of pilgrimage", says Hararanga,

Eka nāma bighana harata.

But it is one and only name (of God ?) that removes all the troubles.

(64) *Rāgiṇī Bhairavī,⁵ Tāl Tritāl,*
Madhya Laya (Medium Rhythm)

(64) Translation

Sthāyi :

Jāya tū mana guru charaṇa śaraṇa,
Eka bhāva dharata antara mō ghana ;

One must seek refuge in the feet of a guru,
One must cherish deep respect within one's heart ;

Antarā :

Jōi jāvata jana sad-guru kē śaraṇa,
Vākō harata chatara bhavabandhana.

Whoever takes refuge in a good guru,
Is made free by the wise,⁶ from wordly ties.

¹ A continuation of the first part, which was published in this *Journal*, in its January 1946 number.

² "Guru-mahimā" means "the greatness and glory of a Guru."

³ The three names of Tritāla (Tintāla, Tritāla and Trivāṭa) all mean "three-beats."

⁴ The name of the composer of this song.

⁵ This *rāgiṇī* as such depicts sorrow, at its best ; however, it is also employed to depict other themes or sentiments ; in the midst of deep agitation, it (Bhairavi) depicts peacefulness, with a strong devotion.

⁶ It refers to the "Guru."

(65) *Rāg Kēdār, Tritāl, Madhya Laya*(65) *Translation**Sthāyī :*

Sōcha samajha mana mīta piyaravā, Think and understand, oh dear friend,
Sadguru nāma karē sumaranavā; Remember the name of a good guru;

Antarā :

Gharī pala pala umara ghatata saba, Age diminishes with the lapse of seconds
Ajahū chēta mati manda chatarvā. and moments,
Even now, wake up and shun foolishness !

(66) *Rāgiṇī Dēsh, Tritāl, Vilambit
Laya (Slow Rhythm)*

(66) *Translation**Sthāyī :*

Lāga rahyō mana sadguru kē charana, My mind is attracted towards the feet of
Nija para bisara gayō hamarō mana; my good teacher ;
It has forgotten its own self ;

Antarā :

Māta pitā saba chhina kē sangāthi, Parents accompany one for a moment
Sācha ēka parabrahma dayāvana. only,
The one and the only truth is *Parabrahma*,¹
the Merciful One !

(67) *Rāg Khamāj, Tritāl, Madhya Laya
(Medium Rhythm)*

(67) *Translation**Sthāyī :*

Namana karū mī sadguru charaṇā, I make an obeisance to the feet of a
Saba dukha haraṇā bhavanistaraṇā; worthy guru,
Who is the healer of misery, the one who
enables one to swim through the ocean
of life ;

Antarā :

Shuddha bhāva dhara antahkaraṇā, One must cherish pure thoughts within
Sura nara kinnara vandita chaṇā. one's heart,
Even the gods and kinnaras² pay homage
to him.³

(68) *Rāg Yamana, Tāl Tritāl, Madhya
Laya*

(68) *Translation**Sthāyī :*

Guru bina kaisē guṇa gāvē, Without a guru how can one extol the
Guru na māmē tō guṇa nahī āvē, virtues of God,
If one does not respect the guru, one can-
not learn the art (of music),
Guṇī jana mē bēguṇī kahāvē; And he would be called ignorant in the
company of connoisseurs ;

Antarā :

Māmē tō rijhāvē saba kō, If one respects him (the guru), one can
Charana gahē Sādiqana kē jaba, please every heart,
Ever since he has laid himself at the feet
of *Sādiq*,⁴
Āvē achapala tāla sura. He can learn *tāla* and *svara* so steadily!

¹ It refers to God, the Supreme Being.² A "kinnara" is supposed to be a singer at the court of gods.³ It refers to the "Guru."⁴ It seems to be the name of some Muhammedan teacher of music.

(69) *Rāg Dē-hkār,¹ Matta³ Tāl*(69) *Translation**Sthāyī :*

Pāka nāma Guru kō raṭa mana nisa dina, Utter the sacred name of the guru every-day,
Jāsō hōta turata bhava sindhu tarana ; Whereby you can soon cross the ocean of this life ;

Antarā :

Jōi jōi sharaṇāgata guru charaṇā bhuja, "Whoever takes refuge in the feet of the guru,
Pāvata Hararanga nita paramātama. Finds the Supreme One," says Hararanga.

(70)

(70) *Translation**Sthāyī :*

Jō guru kripā karē, If the Guru favours,
Kōṭika pāpa kaṭata pala chhinamō ; A crore sins are wiped off within a moment ;

Antarā :

Guru kī mahimā Hara sambhārī, *Hara*³ sings (remembers) the glory of the Guru,
Bēda purānana saba hi bichārī, The Vēdas and the Purāṇas have thought on it,⁴
Brahma Vyāsa roṭē pala chhinamō. And God Brahmā and *Vyāsa*⁵ have repeated it every moment.

(71) *Rāg Hamīr, Tritāl, Madhya Laya*(71) *Translation**Sthāyī :*

Guru bina kauna batāvē bāṭa, But for a guru, who can show the path;
Baḍā vikaṭa Yama—ghāta ; Hideous is the way to Yama's abode;

Antarā (1) :

Bhrānti kī pahādi nadiyā bichamō, Huge rivers of delusion flow, in the midst of which there is a pillar of pride ;
Ahankāra kī lāṭa ;

Antarā (2) :

Kāma krōdha dō paravata thāḍē, There are two mountains of lust and anger, with which is the thief of greed ;
Lōbha chōra sangātha ;

Antarā (3) :

Mada matsara kā mēha barasata, The clouds of pride and passion are causing the rain,
Māyā pavana bahē dāta ; While the wind of illusion blows so liberally !

Antarā (4) :

Kahata Kabirā sunō bhāi sādho, *Kabir*⁶ says to his saint colleagues :
Kyō taranā yaha ghāta. "Why should one go through this life !"

¹ It has the following ascent (ārōha) and descent (avarōha) of notes : Sā rē ga pa dha sā ; sā dha pa ga pa ga rē sā. This rāgi is pictured as a "Suratānta," nāyikā but here it depicts an altogether different mood.

² This Tālā here expresses a different mood ; as such it depicts the mood of intoxication (mattatā) :

Units	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	|	
Beats	×	0	2	3	0	4	5	6	0	7	8	9	10	11	12	13	14	15	16	|

³ God Śiva.

⁴ Guru-mahimā.

⁵ Vyāsa Muni, the author of many a Hindu sacred lore.

⁶ A saint poet, who sang prayers for the deliverance of human soul.

VI SONGS HAVING A PHILOSOPHICAL VEIN

This group of compositions has a highly religio-philosophical vein ; they are written in a form of advice to man to abandon wordly ties and merge himself in God, the *Parabrahma*¹. This manifests one of the characteristics of Hindu philosophy, namely, non-attachement to things wordly. The sentiments embodied in these songs characterise the third and the fourth *āshramas*² of human life as they express the idea that this life is futile.

The following songs are songs of non-attachment (*vairagya*) ; most of these are sung in Trital and medium rhythm (*madhya laya*) :

(72) *Rāgiṇī Āsāvārī, Tritāl, Madhya Laya (Medium Tempo)*

(72) *Translation*

Sthāyi :

Arē mana samajha samajha paga dhariyē,	Lay every step after due consideration,
Arē mana, iṣa jaga mē nahī apanā kōi,	No one in this world belongs to us ;
Parachhāi sō ḍariyē ;	Have fear of your own shadow ;

Antarā :

Daulata duniya kuṭumba kabilā,	We should not be enamoured of
Inasō nēha na kabahū na kariyē ;	Wealth, family and other worldly ties ;
Rāma nāma sukha dhāma jagata pata,	It is through the <i>nāma-smaraṇa</i> ³ of Rāma,
	the abode of happiness, the Lord of this
	world,
Sumarana sō jaga tariyē.	That we can attain salvation.

(73)⁴ *Rāgiṇī Tōḍī, Tritāl, Madhya Laya*

(73) *Translation*

Sthāyi :

Neka chāla chaliyē chatara,	The wise should follow the path of good-
	ness,
Prabhu sō ḍariyē, garava na kariyē,	Fear God; do not be proud;
Nahī bharosō yā nara tana kō ;	One cannot be sure of the body ;

Antarā :

Hararanga kahē upadēsa vachana aba,	<i>Hararanga</i> ⁵ gives you a few words of
	advice,
Samajha samajha paga jagamō dhariyē ;	One should lay steps in this world after
	due consideration ;
Manukha janama nahī bāra bāra yahā,	This birth cannot be had oft and on,
Karanā hō sō kariyē chatara.	Do whatever you wish, O wise one !

(74) *Rāgiṇī Tōḍī, Tritāl, Madhya Laya*

(74) *Translation*

Sthāyi :

Kahā nara apanō janama gumāvē,	Why do you waste your life, O man !
Māyā mada viṣayā rasa rāchyō,	Why revel in wealth wine and other
	pleasures of the senses,
Rāma śaraṇa nahī āvē ;	and fail to seek refuge in Rāma !

¹ The Supreme Being.

² Hindu sages have classified human life into four stages (*āśramas*), namely, *Brahmacharyāśrama*, *Grihasthāśrama*, *Vānprasthāśrama* and *Sanyasthāśrama*.

³ It refers to *Smaraṇa-mantra-yōga* (*Japa Yoga*) which means the utterance of God's name and the praise of His six attributes (*śaḍ-guṇas*).

⁴ This *rāgiṇī* is conceived as a heroine separated from her darling ; she is said to charm the deer with the music of her *viṇā* (lyre) ; here this *rāgiṇī* is, however, used to depict an altogether different mood and theme.

⁵ The composer.

(75) *Rāgiṇī Bhairavi, Tritāl, Madhya Laya*(75) *Translation**Sthāyī :*

Sōcha manā tū kauna ghaṭa mē ; Just think in what mould (body) you are ;

Antarā (1) :

Kahā sē tū āyō, kahā jāvēgō, Whence you have come and where you
will go,
Bhējā tujhakō kauna ghaṭa mē ; In which mould you have been sent ;

Antarā (2) :

Kyā tū lāyō kyā lē jāvēgō, What have you brought and what will
you take with you !
Mālīka tujhakō kaunna ghaṭa mē. In what form the Lord has moulded you !

(76)¹ *Rāg Bihāg, Tritāl, Madhya Laya*(76) *Translation**Sthāyī :*

Jāga jivana thōrā thōrā rē, Wake up ! This life is very short,
Samajha samajha dēkha lē : See and think for yourself ;

Antarā :

Sikha manā lē Sadāranga kī, Follow *Sadāranga's*¹ advice,
Bahuta gai aba tō jōgi bhēkha lē. The greater part of life has passed and
now, don the garb of a yōgi.

(77) *Rāg Bhairava, Tritāl, Madhya Laya*(77) *Translation**Sthāyī :*

Guru nāthā sabana kē, nita sumara rē God is the Lord of everyone ; do always
mana, remember Him, for life is so uncertain ;
Jivata chhana bhangur ; If you wish to have wealth and prosperity,

Antarā :

Jō chāhē tū chatura sukha sampada, O wise one,
Mangala nāma kamala mukhasō vada, Utter his auspicious name through your
mouth,
Jāki kṛipā saba pūrata kām. Whose (God's) mercy fulfils all our aspi-
rations.

(78) *Rāgiṇī Āsāvārī, Tritāl, Madhya Laya*(78) *Translation**Sthāyī :*

Hari bina tērā kauna sahāi, You have no other support than that of
Hari,²
Hari bina māta pitā suta banitā kō Who are the aunt, parents, son and wife,
kāhukō māi ; after all, but for Hari, oh *māi*³ !

Antarā :

Dhana dharani aru sampata nagari, Wealth, land, property and town,
Jō mānyō apanai, That are so cared for,
Tana chhuṭē kachhu sanga na chāle, None of these accompanies you while
leaving this world,
Kahā tāhi lapaṭāi. Then why have you given up yourself to
them !

¹ Bihāga is a very popular melody but it is not described in any of the Sanskrit texts it must be a late-comer in the pantheon of melodies. It is said to have been derived from the older melody, Bihāgaḍā.

² It refers to God Viṣṇu.

³ It refers to an elderly woman.

(79) *Rāg Khamāj*; ¹ *Tritāl, Madhya Laya*

(79) *Translation*

Sthāyi :

Arē mana Hara sō karē tū prīta,
Māta pitā sōhī akhila jagata kō,

Love *Hara*,¹
Who is the father and mother to the whole
world,

Anta samē dūjō kō mīta ;

There is no other companion when one
passes away from this world ;

Antarā :

Yaha samsārā jhūtha pasārā,
Hararanga kahē jū sika tāki bhita.

This world and its things are all futile ;
This line cannot be translated.

(80) *Rāg Kāfi, Jhaptāl, Madhya Laya*

(80) *Translation*

Sthāyi :

Santana kē sanga lāga rē tēri āchhi banēgi; Be in the company of the pious ; this
will do you good ;

**Antarā* :

Hansana kī gati hansa hī jānē,
kōi na jānē kūga rē, tēri āchhi banēgi.

Only a swan knows the swan's gait,
which cannot be known by a crow;
Oh, that will do you good.

(81)² *Rāg Yaman, Ektāl, Madhya Laya*
(*Medium Tempo*)

(81) *Translation*

Sthāyi :

Mērā mana bādha linō rē,
Hārē ina jōgiyā kē sāth ;

I have set my heart
On this saint :

Antarā :

Sadāranga karama karō kyō nā,
Ina prāṇa nātha kē hāth.

Why don't you perform your duties,
being inspired by your faith in God !

(82) *Rāgiṇī Bhairavī, Tāl Jhampā*,³
Madhya Laya

(82) *Translation*

Sthāyi :

Hari kō bhajana hai jaga mē sukha-kāri ; *Hari-bhajana*⁴ is the giver of pleasure in
this world ;

Antarā :

Kāhē kō vritha janama bigōvē hē nara nārī. Why do you fruitlessly pass away your
life, oh man, oh you woman !

(83) *Rāgiṇī Bhairavī, Rūpak*⁵

(83) *Translation*

Mata kara mōha tū, Hari bhajana kō
māna rē ;

Do not be fascinated ; have faith in Hari
bhajana ;

Nayana diyē darasana karanē kō,
Shravaṇa diyē suna gyāna rē ;

Eyes are endowed to have a sight of God,
and the ears for listening to a talk of
knowledge ;

Vadana diyā hari guṇa gānē kō,
Hātha diyē kara dāna rē ;
Kahata kabira sunō bhāi sādho,
Kanchana nipajata khāna rē.

The mouth is bestowed to sing God's
virtues, and the hands for almsgiving ;
Says Kabir to a company of *sādhus*,⁶
"Thus⁷ the mine of gold can be achieved."

¹ *Rāgiṇī Khamāj* (Khamā-icī) is grouped under *Karnāta* (rāga). *Sārangadēva* the author of "*Sangita-Ratnākara*" considers it a minor melody (upāṅga) of *Vēlāvali*, (*Bilāval*). *Khamāj Rāgiṇī* is used to depict themes of passion ; here however, it depicts an altogether different mood and theme.

² *Yaman-Kalyāṇa* is one of the varieties of *Kalyāṇa rāga* which is said to depict heroic sentiment ; it is a comparatively modern melody, treated as an *Uparāga* (additional melody). But from the sixteen century it has been accepted as a generic (*Janaka*) melody.

³ This *Tālā* has seven units (mātrās) : $\frac{7}{1-2-4}$

⁴ Worship of God Viṣṇu.

⁵ This *Tālā* has seven units (mātrās) : Units | 1 2 3 | 4 5 | 6 7 |
Beats | × | 2 | 3 | .

⁶ An ascetic ; he is one of the saint-poets, whose verses have a religio-philosophical vein. The verses of *Tulsidās* and *Sūrdās* were also set to music.

⁷ Through *Hari-bhajana*.

(84) *Rāgini Darbārī, Kānadā,¹
Tritāl, Madhya Laya*(84) *Translation**Sthāyī :*

Samajhata nā mana tū mērā,
Lākha bāra samajhāvata hū māñ,
Kāhē na tajata andhērā ;

I cannot get convinced,
Even after persuading myself for lacs
of times,
Why don't I shun darkness !²

Antarā :

Jhūthī māyā jhūthī kāyā,
Jūthā jagata pasērā ;
Anta samē kōi kāmā na āvata,
Chhatra prabhu ēka tēra.

Worldly riches and this human body are
untrue,
All things of this world are false ;
No one proves useful while departing
from this world,
There is only one support, namely,
that of God.

(85) *Rāg Gauda,³ Sārang, Tritāl,
Madhya Laya*(85) *Translation**Sthāyī :*

Bhaja mana Rāma nāma sukhadāi,
Ghari ghari pala pala avadhi bitata saba,
Fira pāchhē pasatāi ;

Utter the name of Rāma, the Giver of
happiness,
By seconds and moments, time is passing
away ;
At the end, you'll have to repent ;

Antarā :

Bhāi bandhu saba kutumba-kabila,
Dekhata jiyā lalachāi ;
Anta samē kōi kāmā na āvata,
Chatra kahē samajhāi.

Of your friends, family and others,
You feel so enamoured ;
At the end, none of them proves useful,
This is what *Chatra*⁴ has to say and explain.

(86) *Rāg Shankarā,⁵ Tritāl,
Madhya Laya*(86) *Translation**Sthāyī :*

Karanā hō sō kara lē pyārē,
Janama jāta dina raina savārē ;

Do whatever you want to, O darling !
By mornings, nights and days, life passes
away ;

Antarā :

Dhana jobana kachhu thīra nahī hai
Chētanā hō to chēta savārē.

Riches and youth are fleeting things,
Be aware of this, while yet there is time.

(87) *Rāg Dēśkār, Tritāl, Madhya
Laya*(87) *Translation**Sthāyī :*

Bhaja lē Mahēśā manujā pada kō,
Safala karē apāno nara dēha ;

Worship God *Mahēśa*,⁶
And thus make this human life fruitful ;

Antarā :

Taja bhava trēṣṇā mōha jāla saba,
Inasō mudhā chatara jagamō nēha.

Shun your delusions and the desire for
living,
For the love of these, is untrue, oh wise one !

¹ This rāga has the following ascent and descent of notes : *ni sā, rē ga rē sā, ma pa dha ni sā ; Sā dha ni pa, ma pa ga ma rē sā*. This rāgini is one of the varieties of kānadā rāgini which is conceived to represent heroic sentiment according to Hanumāna.

² Ignorance.

³ This rāga has the following ascent and descent of notes : *Sā ga rē ma ga, pa mā dha pa, ni dha sā ; Sā dha ni pa, dha mā pa, ga ma rē, pa rē, sā*. "Gauda-Sāranga" is one of the several varieties of Sāranga rāga.

⁴ Chatur Paṇḍit, the composer.

⁵ It has the following ascent and descent of notes : *Sā ga pa ni dha sā ; Sā ni pa, ni dha, sā ni pa, ga pa ga sā*.

⁶ Śiva.

(88) *Rāg Vasant*,¹ *Tritāl, Madhya Laya*(88) *Translation**Sthāyi :*

Kāhē na lēta prabhu kō nāma,
Mānava bhūla paḍā rē mūdha ;
Ajahū samajha taja saba abhimāna,

Why don't you utter God's name?
You have gone astray, oh stupid one ;
Even now understand and shun pride ;

Antarā :

Apani apani karakē daurata,
Anta samē kachhu n'āvata kāma ;
Pāpa puṇya tērē sācha sangāthi,
Ajahū samjha bhaja Rāma siri Rāma.

You go about for your own interests,
Though nothing proves useful when you
depart ;
Your true companions are your good
actions,
Consider and worship God Rāma while
yet there is time.

(89) *Rāgiṇi Darbāri, Kānaḍā, Ektāl*(89) *Translation**Sthāyi :*

Sumarana kara mana nirguṇa para-
brahma,
Fira pachhatāvēgō tū ;
Māna vrithā abhimāna, jarā kahi arē
arē mana ;

Worship the Supreme Being, who is
nirguṇa,²
Or else you'll repent ;
Consider how futile it is to be proud ;
does not this convince you ?

Antarā :

Jōbana sarūpa tana hō jāvē dahana,
Nahī sātha sangātha kalatra putra batana ;
Jō chāhē mukti kō chatura tū jatana.

Youth as well as its beauty will burn to
ashes,
Neither your sons nor the others will
accompany you ;
Make an effort, O wise one, if you desire
to attain salvation.

(90) *Rāg Multāni*,³ *Tritāl*(90) *Translation**Sthāyi :*

Achapala nāma sāṁ kā bhaja rē,
Achapala nāma sāṁ kā bhaja rē,

Utter steadily the Lord's name,
Utter steadily the Lord's name,

Antarā :

Isamē tujhakō bahota nafā hai,
Dhyāna lagā aura mālā kō japa,
Māyā kō saba taja rē.

This will be of great advantage to you,
Concentrate and count your beads while
uttering His name,
Shun all illusion.

(91) *Rāg Bibhās*,⁴ *Tritāl, Madhya Laya*(91) *Translation**Sthāyi :*

Rabā kō nāma sumara manā,
Jhūṭhi jaga kī bāsanā ;

Remember God's name,
For, worldly desires are futile ;

Antarā :

Dhruva Prahlāda Ajāmila tārē,
Pūji mana kāmānā.

*Dhruva, Prahlāda and Ajāmila*⁵
Should be worshipped.

¹ It has following ascent and descent of notes : Sā ga mā dha rē sā ; Rē ni dha pa mā ga mā ga, mā dha mā ga, rē sa.

² One who is above the three attributes (guṇas).

³ It has the following ascent and descent of notes : Ni sā gā mā pa ni sā ; Sā ni dha pa, mā ga, rē sā.

⁴ It has the following notes : Ni rē ga, mā ga, rē sā, ga pa dha mā ga, pa ga, rē sā. This type (prakāra) of Bibhās originates from the mould Mārvā. According to one school Bibhāsa is a melody of Mēgha and according to another, a rāgiṇi of Panchama.

⁵ The names of Stars.

(92) *Rāg Khamāj, Dhumālī*(92) *Translation**Sthāyi :*

Bhajō rē maiyā rāma gōvinda hari,	Worship <i>Rāma</i> , ¹ who is <i>Govinda</i> ¹ as
Japa tapa sādhana kachhu nahī lagata,	well as <i>Hari</i> , ¹ This does not require the practice of <i>japa</i> ²
Kharchata nahī gaṭharī ;	and austerities,
	Nor does it cost a penny ;

Antarā (1) :

Santata sampata sukha kē kāraṇa,	Offspring and riches are mistaken to be
Jāṣē bhūla parī ;	the cause of happiness ;

Antarā (2) :

Kahata kabirā jā mukha rāma nahī,	"A person who does not utter God's name,
Vō mukha dhūli bhari.	Deserves to be disgraced", says Kabir.

(93) *Rāgiṇi Purvī, Tritāl*(93) *Translation**Sthāyi :*

Mana pachhatai hai avasara bītē,	One repents when the opportunity is
Durlabha dēha pāi Hari pada bhajō,	missed ;
Karama vachana aru hītē ;	Having had this rare birth, one should
	worship Hari,
	By word, deed and with one's heart ;

Antarā (1) :

Sahasa bāhu dasavadana ādi nripa,	Even the <i>thousand-armed</i> ³ king, the <i>ten-</i>
Bachē na kāla bali tē ;	<i>faced one</i> ,
	Could not save himself from the hands
	of Death,

Antarā (2) :

Hama hama kari dhana dhāma sanvārē,	Pursuing his self-interest, he looks after
Anta chalē uthi ritē ;	his land and wealth,
	Which do not accompany him, when he
	departs ;

Antarā (3) :

Suta banitādi jāni svāratha-rata,	Seeing the son and the wife following
Na karu nēha sabahī tē,	their own interest,
Atahu tōhi tajēgē pāmara,	One should not be lost in loving all those
Tū na tajai abahi tē ;	Who will leave you, oh stupid one !
	Why don't you leave them now ;

Antarā (4) :

Aba nātha hī anurāgu jāgu jaḍa,	Awake and love the Lord, oh foolish one,
Tyāga durāsā jitē,	While giving up the desires of your heart ;
Bujhai na kāma-agini, Tulsi kahū,	The fire of the desires cannot be calmed
Viṣaya—bhōga bahu ghītē.	By the ghee of sensual enjoyment.

¹ Epithets of Viṣṇu.² Muttering God's name as well as singing in his praise.³ Rāvaṇa, the King of Lankā.

(94) *Rāgiṇī Āśavari, Tritāl*

Sthāyī :

Kara lē singāra chatura *alabēlī*,¹
Sājana kē ghara jānā hōgā ;

Antarā (1) :

Mitti ōdhāvana mitti bichhāvana,
Mitti sē mila jānā hōgā ;

Antarā (2) :

Nahā lē dhō lē sīsa gunthālē,
Fira vahā sē nahī ānā hōgā.

(95) *Rāg Kālingdā, Tritāl*

Sthāyī :

Prāṇī tū Hari sō ḍara rē,
Tū kyō rahā niḍara rē ;

Antarā (1) :

Gāfila mata raha, chēta savērā,
Mana mē rākha fikara rē ;
Jō kuchha karē bēga hī kara lē,
Sira para kāla jābara rē ;

Antarā (2) :

Kālē gōrē tana para bhūla, tana jāyagā
jarā rē ;
Yama kē dūta pakaḍa kara ghīsē, kaḍhē
bahuta kasara rē ;
Hari bhaja Hari bhaja Hari bhaja prāṇī,
Hari kō bhajana tū kara rē ;
Vrajakiśora prabhu-pada naukā chaḍha
Bhavasāgara kō tara rē.

(96) *Rāg Bibhās, Tritāl*

Sthāyī :

Jāga jīva sumarana kara Hari kō, bhōra
bhayō hai bhāī rē ;
Sad-guru gyāna vichāra kahata hai,
chētō Rāma duhāī rē ;

Antarā (1) :

Nā kōī tērō sajana sanēhi, nā koi bēna
na bhāī rē ;
Jama kī mārā paḍē jaba rōvē, taba tō
kauna sahāī rē ;

Antarā (2) :

Māta pitā kula lōga lugāī, svārtha milē,
sagāī rē ;
Sumarana binā sanga nahī kōī, jīva
akēlō jāī rē ;

Antarā (2) :

Adhamōchana (?) bhavaharana murāri
charana śarana baḍa āī rē ;
Sahājārāma bhaja Rāma sanēhi, dukha
mētana sukhadāī rē.

(94) *Translation*

Finish decorating yourselves, oh wise one,
For you'll have to go to your Lord's home;

You'll have the clay as your covering and
sheet,
You'll have to become one with the clay ;

Have a bath and dress yourselves up,
You won't be coming back from there.

(95) *Translation*

Fear God Hari,
Why have you become so fearless?

Don't remain negligent ; awake while
yet there is time,
Take care ;
Whatever you want to do, do it soon,
Death's hand is ready to crush you ;

Do not run after the beauty of the body,
which will be burnt ;
The messengers of Yama² will catch
and rub the body, and will thus make
good the loss ;
Do worship God Hari, oh do worship
Him ; do say your prayers to Him ;
Mounting the boat of God's feet,
Attain salvation.

(96) *Translation*

Wake up and worship Hari ! The dawn
has set in ;
Thoughts and knowledge derived from
a good guru tell us, that one should
wake up and pray for Rāma's help ;

There is no friend, no dear one, no sister,
no brother ;
On getting a thrashing from Yama²
one weeps, for then there is no support ;

One's parents and different members
of one's family are all seekers of their
own interests ;
Worship is the only thing that helps,
as the soul departs alone ;

Murāri (Viṣṇu) frees him from the recur-
rence of births, who takes a refuge in Him ;
"Worship Rāma with affection," says
Sahajārāma ;³ "He is the Healer of pain
and the Giver of happiness."

¹ It refers to a "belle." ² Yamarāj, the god of death. ³ The composer.

(97) *Rāgiṇi Bhairavī, Tritāl*(97) *Translation**Sthāyi :*

Mōri lāgi laṭaka guru charanana kī, I have had a fascination for the feet of
my guru,
Charana biṇa mōhē kachhu nahī bhāvē, Without whom nothing is palatable to me;
Jhuṭha māyā saba sapanana kī; The rest of the worldly things are delu-
sions of a dream;

Antarā :

Bhavasāgara saba sūkha gaya hai, The ocean of worldly things has dried up
for me,
Fikara nahī aba taranana kī; There is no anxiety of going through the
ocean of life;
Mirā kahē prabhu Giridhara nāgara, Mirā says : "Oh God *Giridhara-nāgara*,¹
Ulaṭa bhai mōri nayanana kī. My eyes have turned to the other side
(of life).

(98) *Rāg Kālingā, Tritāl*(98) *Translation**Sthāyi :*

Kara mana prabhu sē prīti; Direct your love to God !
Aisō samaya bahuri nahī paihō, You won't get such opportunity oft and on
If you lose it once ;
Jai hai avasara bita; The beauty of the body and face shouldn't
lose you astray,
Tana sundara chhavi dēkha na bhūlō, For this is a mere *wall of sand*;²
Yaha bālu kī bhīta;

Antarā (1) :

Sukha sampati sapanē kī batiyā, Worldly happiness and riches are but a
dream,
Jaisē, triṇa para shīta; As they are as ineffective as the dew on
the grass ;
Jāhi karama parama pada pāvē, That action which would help you to
attain salvation
Sōhi karama kara mīta; Should be performed by you, oh friend !
Sarana āyē sō saba hī, ubārē, He saves all those who seeks refuge in Him,
Yahī prabhu kī rīti; In accordance with His way;
Kahai kabīra sunō bhāi sādho, So says Kabīra to the company of saints,
Chilahau bhāi dala jita. The meaning of this line is unintelligible.

(99) *Rāg Khanājī, Tritāl*(99) *Translation**Sthāyi :*

Sumarana kara lē mērē mana, Worship God ;
Tēri bitū umara Hari nāma binā; Life is passing away without uttering
God's name ;

Antarā (1) :

Kūpa nīra binu dhenu khīra binu, Just as a well's without water, a cow's
without milk and a home's without light,
mandara dīpa binā,
Jaisē taruvara fala binā hīnā, Just as a tree's of no use without the fruit,
Taisē prāṇī Hari nāma binā; So is man if he does not utter God's name ;

Antarā (2) :

Dēha naina binā, raina chandra binā, Just as the body's without the eyes, the
night's without the Moon,
Dharatī mēha bina, jaisē paṇḍita vēda The earth's without rain, the paṇḍit's
vihīnā, without the knowledge of the Vēdas,
Taisē, prāṇī Hari nāma binā; So man's without *Hari-nāma*³

Antarā (3) :

Kāma krōdha mada lōbha nivārō, Remove lust, anger, pride and greed
(from your heart),
Chhōda virōdha tū santa janā; Shun enmity, oh pious one !
Nānaka kahē sunō bhagawantā, *Nānaka*⁴ says : "Oh God !
Yā jaga mē nahī kōi apanā. No one is ours in this world."

¹ One of the epithets of Shri Krishṇa.³ Remembrance of God Viṣṇu's name.² That which is liable to be destroyed.⁴ The name of the composer.

(100) *Rāgiṇī Kāfi, Tritāl*
Shāyt :

Rāma nāma rasa pijai,
 Manuja Rāma nāma rasa pijai;
 Taja kusangata satsanga baiṭhē,

Nita Hari-charachā suna lijai;

(100) *Translation*

Relish in the utterance of Rāma's name,
 Enjoy the utterance of Rāma's name;
 Giving up bad company and sitting amid
 good people,
 Listen to God's attributes being sung;

Antarā :

Kāma krōdha mada mōha lobha kō, Shed lust, anger, pride, delusion and greed
 Bahā chitta sē dijai; From your mind;
 Mirā kē prabhu Giridhara nāgara, Mirā's *Giridhara-Nāgara*¹
 Tāhi ranga mē bhijai. Is saturated with the same *rasa*.²

VII SONGS OF A MISCELLANEOUS CHARACTER

This group contains songs on many subjects varying from the most subtle to the most concrete, such as songs on "music" as such, songs sung in praise of kings and Mohammedan Pirs, lullabies and various morning songs.

There are also a few songs describing seasons (monsoon and spring) which are sung in *Mallār*³ and other *rāgiṇis* such as Vasant and Bahār which manifest the beauties of Spring. Such songs are also found in other *rāgas* and *rāgiṇis*. These songs could have been included in the group⁴ of songs pertaining to seasonal festivals (*varshōtsava*).

Songs on music as such deal with the attributes of *rāgas* and *rāgiṇis* or they may have to say something about the notes⁵ constituting a particular *rāga*. The latter songs are termed as *Lakshana*⁶ *gītas*. In these we have a full picture of the *rāgas* as well as an inkling into the principal notes (*vādī svaras*), the notes of secondary importance (*samvādī svāras*). Ordinary notes (*anuvādī svaras*) and notes which do not appear at all (*vivādī svaras*). At the same time we have a knowledge of the note from which a *rāga* begins (*Griha*) and the note where it generally ends (*nyāsa*). In short, these songs enlighten us as regards the structure and character of a *rāga*.

Besides the details concerning the art and science of music (*sangitā-shāstra*), we have an inkling into subtilties of sound (*nāda-bhēda*), the quarter tone (*shruti*). All these details as well as various subtilties of sound are to be mastered by the musician as well as the connoisseurs (*guni-jana*).

The following song stresses the importance of maintaining *tāla* and *sura* which are regarded as the soul (*jīva*) of music. This song is a *Dhruvapada*, set in *Tāla Chautāla*. Most of such songs are *Dhruvapadas*, sung in *Chautāla* or *Jhaptāla*.

¹ Shri Krishna.

² Bhakti rasa.

³ A melody which depicts the charms of the rainy season.

⁴ Group II—published in the preceding part of the same article.

⁵ Whether the notes are flat (*kōmal*), sharp (*tivra*) or natural (*shuddha*).

⁶ Songs (*padas*) describing the characteristics of a *rāga*.

(101) *Rāgiṇī Darbarī Kānadā, Tāl Chautāl*(101) *Translation**Sthāyī :*

Achhara nāda kō bhēda jō pāvē,

One who knows the mysteries of words and sound.

Kaṇṭha kara dikhāvē, tata bitataki
gahatā sō,

One who can sing by heart with the accompaniment of string and skin instruments ;

Tāna rāga ki dharana sura achhara ki
bharana,

One who can sing rāga and its tānas, giving regard to word and notes,

Rupa ranga ki karana, jānata uṭhāyana
ki bhātāsō ;He can know the rūpa¹ and ranga² merely at the beginning of the stage ;*Antarā :*Tikita dhikiṭa taka thauga dima takiṭa
taka dhadhi,Tikita dhikiṭa taka thaṅgā dima takiṭa
taka dhadhi³Gana dhā takā, thaugata kiṭa taka dhā
dhigana dhā ;Gana dhā takā thaugata kiṭa taka dhā
dhigana dhā.

Lē uṭhāya dugana karē sura sōdha,

Thus beginning he can sing duguna with the notes.

Chetasinga kē shravana kasauti,
Tāmē guni kasāvē ;

"This is an exercise for the ears which the gunijana has to go through" says Chētsing,

Taba gunijana mērā bhātāsō.

"Then only he is a gunijana⁵ according to me."(102) *Rag Yaman Kalyāṇā, Tāl Chantāla*(102) *Translation**Sthāyī :*Tāna tāla sō hi gāiyē,
Anagina tāna gāiyē sunāiye bōgi,
Parasata hai Sudha rāga ;Sing tānas⁶ in a rhythm,
Sing innumerable tānas,
Maintaining the purity of rāga ;*Antarā :*Suna ata hi alapata mudrāmē gāvē,
Tāna pramāna kō rijhāvē,
Mānō gunijana kē hota kaṇṭha.Singalāpa⁷ to the accompaniment of mudrā⁸
Measured tānas captivate people.
And are committed to memory by the artist.(103) *Rāgiṇī Alhaiyā Bilāvala,⁹ Tāl Chautāl¹⁰*(103) *Translation**Sthāyī :*Alhaiyā Bilāvala rāgiṇi bichitra māi ;
Sakala Sura shuddha jāmē,
Rasa shānti kō dikhāi ;O friend rāgiṇi Alhaiyā Bilāvala is wonderful !
In it all saras are pure (natural)
And it manifests shānta rasa ;*Antarā :*Dhaiyata jāmē vādi gandhāra samavādi,
ni dvaya guni chatura sumata,In it dha is vādi and ga is samavādi,
The wise and the intelligent artist uses
two "nis",¹¹

abhinava ranga dēvatāt.

These have a new divine colour.

¹ The picture.² The nature.³ The words (bōlas) played an Pakhāvaj (Mridang).⁴ The same words (of the song) are repeated in a "dugano" but within half of the fixed time.⁵ A genuine artist and connoisseur.⁶ Permutations and combinations of the notes of a rāga.⁷ That music which is made of svaras and no words ; this is known as Rūpā-lapti (ālāpa) which is regarded as the highest.⁸ Symbols.⁹ This melody is visualised in the person of a damsel anxious to meet her lover (priya samāgamanē dharita manasā).¹⁰ It is a Dhruvpad, composed of twelve mātrās. The Dhruvpadas have a serious character (gambhīra prakṛiti).¹¹ Flat (Kōmal) and natural (Shuddha).

The seven notes of the Hindus have colours and are connected with Divinity. All the notes are assigned different colours, as well as rasas. Thus Ragini Alhaiyā Bilāvala depicts Shānta Rasa according to Pandit Bhātkhaṇḍe.

The following song is also a Dhrupada, set in Chautala. It is to be sung in Shri Rāga which is a twilight (sandhiprakasha) rāga, used for devotional purposes. The fundamental rasa produced by it is *Shānta rasa*.¹

There are many padas describing the characteristics (lakṣaṇas) of Shri-Rāgas; most of these are Dhrupads which are congenial to the seriousness and serenity of this Rāga. It is one of the six main Rāgas, described by the four *Matas*.²

(104) *Rāg Shri, Tāl Chautāl*(104) *Translation*

Sthāyi :

Hararanga aba kahata
Rāga sandhiprakāsha kō,
Ri dha kōmala ga ma ni tivara,
Sādhata Shubha lachhana kō ;

Hararanga³ now tells us of the *Sandhi-prakasha*⁴ rāga.
Which has flat (kōmal) rē and dha
and sharp ni,
Thus accomplishing its good qualities.

Āntarā :

Madhyama tivara pramāna,
Asta samaya sanidhāna,
Kōmala madhyama nishāna
Udaya samaya rūpa kō ;

The sharp "ma" is a sign of the setting hour,
While the flat "ma" is an index of the rising hour ;

Sanchāri :

Vādi nita kōmala sūra.
Rikhaba, aru dha ga bina kara,
Rohana, avarōhana mata
Sampūrana sura sumadhura ;

The flat rē is its vādi.
Svara, and dha and ga are left off while ascending ; the descent is *Sampūrna*,⁵
composed of Shuddha notes ;

Ābhōg :

Gāvata rasa shānti prachura,
Tana mana kara pāka chatura,
Jo nara sudha bhāva bhītara,
pāvata ridha sidha kō.

They sing this rāga ; which is full of Shānta rasa,
And which purifies the hearts of the wise ;
One who is pure in heart, achieves success and prosperity.

(105) *Rāg Shri, Tāl Chautāl*(105) *Translation*

Sthāyi :

Siri rāga guni bakhāne.
Pūrvi kō mēla mānē ;
Arohana dha ga bina kara,
Gāvata dina aṣṭajāmē ;

The connoisseurs praise Shri Rāga,
Which has Rāg Pūrvi as its *Mēla*,⁶
While ascending it leaves dha and ga,
And is sung at the setting of the sun ;

¹ Peaceful sentiment which is not included by some writers, among the eight rasas (asta-rasa).

² Shivamata, Kalināth Mata. Hanuman mata and Bharat mata. There are other matas besides these. There are as many schools of music as there are musicians.

³ The name of the composer.

⁴ Shri rāga, which is a twilight melody.

⁵ The three kinds (jātis) of rāga as described in scriptures : Sampūrna (composed of seven notes), Shādhava (of six notes) and ōdhava (of five notes). There are permutations and combinations of these three jātis.

⁶ The mould (thāṭa); Pūrvi is regarded as a generic melody by latter writers.

Antarā :

Gaurī mālavi tira-bana,
Purbi Tanki ati sōbhana ;
Bhārjā pancha saba sumata,
Indraprastha mata pramānē ;

Gaurī, Mālavi, Trivēni, Pūrvī and
Tanki are beautiful,
They are its five *wives*¹ in accordance
with *Indraprastha*² Mata :

Sanchārī :

Manahara Bhupāla Jēta,
Kalyāna Hamira Hēma ;
Pūrbyā aru Shyāma kahata,
Rāga putra aṣṭa nāmē ;

Manahara, Bhupali, Jait,
Kalyāna, Hamir, Hēma, Purbyā and
Shyāma are known as its eight *Putra*
*rāgas*³

Ābhōg :

Guna sāgara Bihanga,
Mālava gambhīra sindha ;
Gaḍa Gauḍa Kalyāna Kumbha ;
Bhāvabhaṭṭa mata pramānē.

Rāg Bihanga, Guna-sāgara, the serious
Mālava and Sindha,
Gada, Gauda, Kalyāna and Kumbha,
Are its sons in accordance with *Bhāva-*
*bhaṭṭa Mata*⁴

(106) *Rāg Tōḍī, Tāl Jhapṭāl*

(106) *Translation*

Sthāyī :

Āda anāhata nāda upajō jagata mē,

The first sound which took its birth in
the world was *anāhat*,⁵

Tākō karū dhyana pāka mana ghaṭa mē ;

On which I meditate with pure heart and
body ;

Antarā :

Kharaja Rikhaba gandhāra,
Sapta sura āhata milāya,
Nirguna Brahma vyāpaka jagata mē.

*Kharaja*⁶ *Rikhaba*⁷ and *Gandhāra*,⁸
The seven *āhat*⁹ notes are mixed,
*Nirguṇa Brahma*¹⁰ reigns the world.

(107) *Rāg Yamankalyāna, Tāl Chau-*
tāla

(107) *Translation*

Sthāyī :

Prathama sharīra gyāna,
Nāda bhēda tina sthāna,

Firstly comes the knowledge of the body.
As the mystery of sound lies in the *three*
*parts*¹¹ (of the body)

Dvābishanti shruti shuchi svāra,
Dvādasha bikarata bakhāna ;

The *shrutis*¹² are twenty-two and the
pure (natural) with the *bikarata svaras*¹³
are twelve.

1 Each Rāga has its wives (Rāginis)

2 One of the schools of music.

3 Each Rāga has its sons (putras) which vary according to different schools of music. There are generic (janaka) rāgas and derived (janya) rāgas.

4 One of the schools of music, named after its pioneer.

5 That nāda (sound) which is beyond human comprehension.

6 Sā 7 Rē 8 ga.

9 Finite.

10 The Supreme Being who is free from the three guṇas, namely, Sāttvik, Rājaisk and Tāmasik.

11 Navel (nābhi), throat (kaṇṭha), head (Mūrdha sthāna) : these three parts are connected with the production of sound.

12 The quarter tones.

13 Sharp (tīvra) and flat (kōmal) notes.

Antarā :

Vansha jāti varṇa dvīpa,
Chhanda rishī viniyōga (?),
Shruti jāti tīna grāma,
Eka-īsa mūra jāna ;

Shuddha kūṭa bhēda tāna,
Parastāra mēru jana,

Nastō disha prabōdhana,
Sādhāraṇa kō bīdhāna ;

One must know the family (jāti) and *varṇa*¹ of these notes and also the use of meters (chhandas) ;
One must have the knowledge of the *jātis* of *shrutis*² and the three *grāmas*³ and the *Murchhanās*⁴ which are twenty-one.
One must know the secrets of pure and mixed tānas and also the process of extension of the notes,
These lines cannot be translated.

Ābhog :

Kākali sura aru antara,

Chatura barana alankāra,
Jāti lachhana kamāta,
Ratnākara mata pramāṇē.

One must know the *kākālī*⁵ svara with all its secrets
And the four *alankāras*,⁶ its kind and its characteristics according to *Ratnākara Mata*.⁷

(108) *Rāgini Bihāg, Tal Chautāl*

(108) *Translation*

Sthāyī :

Uttama gāya vō gāya sunāya,
Saba guṇiyana mīle sācha surana kī
upajāsō karata māna ;

He sings best who sings genuine notes before connoisseurs, who measures you by the standard of notes ;

Antarā :

Sudha bānī sudha sangata kē,
Byōrē myārē kara dikhāvē panchanamē
Kara kē kara bayāna.

He must be able to analyse through pure words.
The details of harmony before a company of five or more people ;
He must be able to state the vādi, samvādi, anuvādi and vivādi notes.

(109) *Rāg Bhupālī, Tal Tivrā*

(109) *Translation*

Sthāyī :

Prathama sura kō sādhe,
Shuddha bikarata sabahu dvādaśa,
Grāma murchhanā mēla daśa bīdha,
Guṇiyana sumata ādē ;

Firstly one should practise the notes, All the twelve pure (natural) as well as the sharp and flat notes ;
The *grāmas*,⁸ *murchhanās*⁹ and the ten moulds (Ihālās)
are firstly known by the connoisseurs

Antarā :

Khādavōdava sampurana kē,
Rāga tatva agādhē,
Guru binā nahī gyana kabahu na
Chatura kara tu yādē.

The knowledge of *Khādava*,¹⁰ *Odava* and *Sampūrna*, which constitute the deep essence of *Rāgas*, cannot be obtained without a Guru ;
“Bear this fact in mind,” says *Chatura*.¹¹

¹ Kind of colour and rasa assigned to different notes.

² Different shrutis are assigned rasas and are classified into groups.

³ The grāmas or resting places are three viz. ga, sā and ma.

⁴ Sound (dhvani) heard between the two notes ; these are twenty-one.

⁵ Low and sweet tone.

⁶ Graces or embellishments.

⁷ According to the author of *Sangita-Ratnākara*.

⁸ The three grāmas are kharaj (sā) madhyam (ma) and nikhād (ni). A grama means a resting place.

⁹ The twenty-one tones (Murchhanās)

¹⁰ The three kinds (jātis) of *Rāgas*.

¹¹ This name stands for Pandit Bhātkhandē.

(110) *Rāg Mārvā, Tal Chaqtāl*(110) *Translation**Sthāyī :*

Gāyaka saba mila bichāra lō yā bāta kō,
 Sudha astāi sudha achhara,
 Tāna rāga kī sangata mē
 Dharana murana,
 Sundara taba kahiyē vākō ;

Oh singers, consider this matter !
 Pure *astāi*,¹ pure words and *tanās*² of
 a rāga, all go hand in hand ;
 When these are maintained, we may call
 it beautiful ;

Antarā :

Okta jōkta kāba mē dhārē anuprās,
 Taba Dhrupada banāya gāvē sunāvē,
 Aisō jō hōvē srēṣṭa sravana sukhadāya.

Having mastered the art of alliteration
 one should create and sing Dhrupad ;
*Such*³ noble music pleases the ear.

(111) *Rāg Panch Kalyāna⁴, Tāl Ektāl*(111) *Translation**Sthāyī :*

Pancha barana pancha rāga,
 Gāvō guni saba mila kē,
 Rāga tāna kē paramān.

Rāgas of five kinds !
 Sing them oh *guni-jana*⁵
 Maintaining the rāga, sing the tānas.

Antarā :

Ārohi avarōhi sankīrana sampūrana,
 Kahē Miyā Tānsēna,
 Nyāro nyāro kara dikhāyō.

The ascent and descent are *sankīrana* and
sampūrna,⁶
 So says *Miyā Tānsēn*⁷ ;
 Who analysed them all (the five rāgas).

(112) *Rāg Shankarā⁸, Tāl Tritāl*(112) *Translation**Sthāyī :*

Anahata āda nāda kō bhēda na pāyō,
 Pachhatāyē guni jana gyāni ;

The mysteries of the first anāhat sound
 are not unravelled ;
 For which the guni-janas and savants
 have repented ;

Antarā :

Balahāri una gurana kē Ahemada,
 Jina-kē bēda bhēda kī bāta bakhāni.

*Ahemad*⁹ has dedicated himself to his
 Guru, who has praised the mysteries of
*l'ēda*¹⁰

(113) *Rāg Yaman Kalyān, Tāl Tritāl*(113) *Translation**Sthāyī :*

Āhata anahata bhēda nāda kō,
 Prathamā bhēda shrutiyaṇa s̃ hōvē,
 Anahata muni-jana dhyāna dharata jaba ;

The first secret of infinite anāhata and
 finite āhat sound lies in the shrutis¹¹
 When the sages meditate on infinite
 sound ;

Antarā :

Nābhi kaṇṭha aura mūrdhasthāna s̃,
 Mandra madhya aura tāra hōvata ;
 Sapta surana kē nāma bhayānē,
 sā rē ga mā pa dha ni .
 sā ni dha pa ma ga rē sā.

From the navel, throat and head,
 emerge the *mandra*, *madhya* and *tāra* octaves¹²
 The names of the seven notes are as
 follow :— sā rē ga mā pa dha ni
 sā ni dha pa ma ga rē sā.

¹ A composition of the Khyāla school of Music.

² Permutations and combinations of notes.

³ Dhrupad school of music which has a high poetic and svara element.

⁴ It is a combination (mīśraṇa) of five rāgas : Shuddha-Kalyāna, Hēma-Kalyāna, Yaman-Kalyāna, Shyām-Kalyāna and Hamir-Kalyāna. This melody seems to be one of the innovations introduced by Tānsēn and other Muhammedan musicians.

⁵ Connoisseurs, lovers of art.

⁶ The two jātis of a rāga.

⁷ The name of composer, who is said to have lived in Akbar's Durbar.

⁸ Rāg Shankarā has the following ascent and descent of notes: sā ga pa ni dha sā ;
 sā ni pa, ni dha sā ni pa, ga pa gā sā.

⁹ The name of the composer.

¹⁰ Gāndharva-vedā, which is concerned with music.

¹¹ The twenty-two quarter-tones.

¹² The names of the three octaves employed in Hindustānī music,

(114) *Rāg Mārcā, Tāl Tritāl*(114) *Translation**Sthāyī :*

Tata bitāta ghana sushīra saba mānata,

*Tata*¹, *Vīlata*², *Ghana*³ and *Suśīra*⁴ are so called,

Bājē chatura bidha shāstra bakhānata ;

These four musical instruments being praised by the scriptures.

*Antarā :*Bīna mridanga jhānjha murli gata,
Bhēda ananta chatura guṇī jānata.The secret of the *Bīna*⁵, *Mṛidanga*⁶, *Jhānjha*⁷ and *Murli*⁸ is known by the wise connoisseur.(115) *Rāg Mārcā Chautāl, Vilāmbit Laya*(115) *Translation**Sthāyī :*

Saba milā bichāra lēho,

Consider this matter all of you together,

Yā bāta kī sudhatāi sudha achhara,

Pure words (and purity of rāga) and

Tāna rāga kī sangata sō, dharana Murana
sō dhariyē,its tānas should be sung in *dharan*⁹
and *murān*¹⁰ ;

Taba kahiyē yāko gāyaka ;

Then only one can be called a true
*singer*¹¹ (*gāyak*) ;*Antarā :*Uktī kūtī kāvya me dharē anūp sēsa taba.
Dhrupada banāya gāya sunāya,Only when one can use device and proper
statement in poetry, he is incomparably
great ;

Aisē srēṣṭa sukhadāyaka :

One must make a Dhrupad and sing it,
so great and such a giver of happiness
he¹² is !Sudha bān¹³ liyē, ālapa karana kiyē,According to particular school of music,
one must sing *ālāp*,¹⁴Tānana rāga-ranga-jhara milāya,
Taba kahiyē yāko gāyaka ;And must shower tānas of the rāga,
Then and then only he can be called a
gāyaka (singer) ;Yē guṇa dēkha dēkha, je sakala bidyā-
bāna,
Guṇanidhāna Rājā Chēṭsinga bahu
lāyaka."One must look for these qualities in all
learned musicians and experts,"
So says *Rājā*¹⁵ *Chēṭsing*, the worthy one.

There are a few songs sung in praise of Mohammedan kings such as Akbar and Mohammad Shah. The latter was called Mohammad Shah Rangilē on account of his great love and patronage of the fine arts. Hence there are some songs sung in his praise. King Akbar was also extolled for his patronage of art and artists.

Some of these songs are Dhrupads as these were in great vogue in the Mughal Durbār. There are a few other songs that employ tālas other than Chautāl.

¹ Stringed instruments ; ² A skin instrument.

³ An instrument which is neither of the first nor of the second kind ; it is played by beating it.

⁴ An instrument which can be played by blowing air into it.

⁵ Specimen of the first kind of musical instrument.

⁶ Pakhāvaj which belongs to the second class.

⁷ Cymbals. These are played by hands.

⁸ The flute which belongs to the last category.

⁹ and ¹⁰ "Dharan" and "Murān" are the graces adopted while singing.

¹¹ One of the grades assigned to musicians.

¹² A Dhrupad singer.

¹³ The school of music ; there are four chief schools (bānīs), named after the pioneer musicians.

¹⁴ The "ālāp" is sung in the beginning, in accordance with the Dhrupad school.

¹⁵ The composer of this song.

(116) *Rāg Sugharāi*,¹ *Tāl Ektāl*(116) *Translation**Sthāyī* :Tū hai Muhamada Shah Durabāra,
Nizāmmuddina Sujani ;You are our Court oh Muhammad Shah !
You are the clever Nizzāmmuddin !*Antarā* :Jōi jō rijhāvē sōi faramāvē,
Sadāranga tōrē guna gāvē,
Nizammuddina SujāniOne who pleases has to command,
*Sadāranga*² sings in your praise,
Oh clever Nizzāmmuddin !(117) *Rāg Shri, Tāl Sūltāl*(117) *Translation**Sthāyī* :Āyō ayō rē Balawantsā āyō,
Chhatrapati Akbara !The strong King Akbar, the Emperor,
has arrived !*Antarā* :Sapta dvīpa zaura aṣṭa disā nara-narēndra
Ghara ghara thara thara ḍara.He is the king of seven islands and eight
directions !
For fear of whom each and every house
shudders.(118) *Rāgiṇī Kēdār*,³ *Tāl Chautāl*(118) *Translation**Sthāyī* :Chaturanga gāvō saba guniyana milē
Chadhō Mahārāja Bahādura ;Sing *Chatranga*,⁴ all of you, together !
Mount, oh king Bahadur !⁵*Antarā* :Pūrana pratāp dēta, Guniyana ko dētā
ādhār.You spread the light of perfect glory.
You support and patronise artists !(119) *Rāgiṇī Āsāvāri, Tāl Chautāl*(119) *Translation**Sthāyī* :Ata pratāpa tēja tērō jaga mē hō,
Rāva Rajē Bahādura ;Let your glory shine in splendour in this
world,
Oh Lord Bahadur !*Antarā* :Nāma sunata guni āvata dhāya dhāya ;
Pāvata mana ichhā fala ;
Tina kō ādhāra.Hearing your name, the gunijana come
up running ;
They fulfil their hearts' desire ;
You are their support !(120) *Rāgiṇī Pūrvi, Tāl Ektāl*(120) *Translation**Sthāyī* :Pira Nizammudina Auliyā,
Saba mēri ichhā dō bharapūr ;Oh Pīr *Nizzāmmuddin*⁶ Auliyā !
Fulfil all my desires ;*Antarā* :Dōu jahā mē dīna Imān,
Pāṭh ānanda sahita dhana,
Jō kijē māmūr.⁸In both the worlds, *Imān*⁷ is the religion ;
I shall have riches and happiness,
if I have morality.

¹ It has the following notes : dha pa, ma rē, ṇi sā, rē, ga ma, rē, sā, ṇi pa, ma pa, ga ma, rē sā. This is a variety of Kānaḍā rāgiṇi, having its birth from Kāfi thāla (mould).

² The composer.

³ According to Nārada, the author of "Sangīta-makaranda," this rāgiṇi belongs to Mēgha Mallār.

⁴ The song of the "four parts" of the army (chaturangīṇi sēnā).

⁵ Bahādur Shāh, who was a Mughal king.

⁶ A Muhemmedan Pīr.

⁷ Faith, truth.

⁸ 'Māmūr', which means 'morality' ('niyat').

The following song is a prayer to Pīr Nizāmī :—

(121) *Rāgiṇī Pūrvī, Tāl Tritāl*

(121) *Translation*

Sthāyī :

Naiyā mōri pāra karō rē, aba Nizāmī ; Now help me, oh Nizāmī, to reach the shore !¹

Antarā :

Tuma hō Pīra gambhira, gyāna anta- You are grave and omniscient, oh Pīr !
rajāmi.

(122) *Rāgiṇī Tōḍī, Tāl Tritāl*

(122) *Translation*

Sthāyī :

- Hamārē tō jē-hi Saravara Haj Mirāji, Our only support is your name, Oh
Tēhārē nāma kō ādhār ; Saravara Haj² Mirāji !

Antarā :

Mana ḍōrē jāmē gunda pāū, Wherever the mind wanders and gathers
Sō hī kara rakhū abahū haravā. flowers, I shall weave a garland of these.

(123) *Rāg Fāman Kalyān, Chautāl*

(123) *Translation*

Sthāyī :

Pīra Dastagīra Hajrata, Oh Pīra Dastagīra Hajrat.
Tuma Guru Sāhēba, isa bašara You are our Guru, this body (man)
Apanō hai, karama karē mērē ; belongs to you ; favour me ;

Antarā :

Kiyō bīdhyādāna sabana kō, You have imparted knowledge to all,
Yaha jaga bakhānata, which (act) is praised by the world,
Rakha bēga dikhāvō, (This line cannot be translated).
Apanō karama karē mērē. Be gracious towards me.

(124) *Rāg Pūrbī, Tāl Ektāl*

(124) *Translation*

Sthāyī :

Ye Mēhbūba Pīrē Chēsti, Oh Mēhbūba Pīr Chēsti,
Hazrat Sultān Nizāmuddīn Auliyā ; Hazrat Sultan Nizamuddin Auliyā !

Antarā :

Kartāra āpī banāyō nūra tē, God Himself has created you out of
Māmūrē Sūrata khūb. His own Light ;
There is great resemblance in the faces !

(125) *Rāg Bhairava, Tāl Jhaptāl*

(125) *Translation*

Sthāyī :

Maunadi maunadi japata hū raina dina, Day and night, I remember Maunadi³,
Baḍē tuma Pīra jaga dina khvajā ; The great Pīr of the world and the lord
of religion ;

Antarā :

Nāma kē liyē sē tapata saba kaṭata hai, "By remembering the (your) name, the
intensity of miseries is mitigated;
Kaṭata dukha fanda yuhi, Rāva Rājā. Thus all troubles are lessened, O Rāva
Rājā !"⁴

¹ To attain salvation.

² A Muhammedan Pīr.

³ A Muhammedan Pīr.

⁴ It refers to the Pīr, who is said to be the Lord of the world.

(126) *Rāgini Pūrvī, Tāl Tritāl*(126) *Translation**Sthāyi :*

E Makdūma Sāhēba Bilāyat ;
Saba bidha lāyaka kinē, Allāyē Rasūl

Oh Makdum¹ *Sāhēb Bilāyat*² !
You are the one who makes us worthy
and fit,
Oh messenger of Allah !

Antarā :

Saba mila āyē Auliyā *Ambiyā*,³
Chahū chōka⁴ mē tumhāri dhūm.

All saints and prophets have come ;
On all the four sides of the courtyard
there is noise and bustle ;

The following are a few morning songs ; these are set in morning
(*Sandhiprakāśa*)⁵ rāgas and are sung in a variety of tālas :

(127) *Rāg Bhairava*(127) *Translation*

Jāgiyē Gōpāla dūhō dhauri gaiyā
Sada-dūdha matha pīvō dhaiyā ;
Bhōra bhayō vana tama chara bōlē,

Wake up, oh *Gōpal*,⁶ milk the white cow,
Churn the milk and drink the curds,
The dawn has set in and the owls are
making a shrill noise,

Ghara ghara gōpa bagara saha kholē ;

The shepherds are opening the yards
of their houses,
The Gōpīs are washing the churns,
And are churning their curds ;
Your playmates have come to call you,
They sing the name of Shri Krishna ;
I shall change the (your) ornaments
and clothes,

Gōpi rai mathanivā dhōvē,
Apanō apanō dahiyo bilōvē ;
Sanga kē sakhā bulāvana āyē.
Krishna nāma lēlē saba gayē.
Bhūṣana basana palāṭa paharāū.

And shall make a *Chandanatilak*⁷ on Thy
forehead ;

Chandana tilaka latāta banāū,
Chaturbhuja prabhu Shri Govardhana
dhārī,
Mukha chhābi para bala gai mahatāri.

Oh God Krishna, the four-armed-one,
oh, *Govardhana Giradhari*,⁸
I have dedicated myself to your phy-
siognomy.

(128) *Rāg Bhairava*⁹(128) *Translation*

Lālana jāgō hō bhayō bhōra,
Dūdha dahi pakavāna miṭhāi
Lājē mākhana rōṭī bora ;
Vikasē kamala vimāla vāṇi saba bolana
lāgē panchhi chahū Ora ;
Rasika prītanā sō kahata Nandarāni,
Uṭha baiṭhō hō Nanda Kishōr.

Wake up, oh darling, the dawn has set in,
Have milk, curds, *pakavāna*,¹⁰ sweets, to-
gether with bread and butter ;
The lotus is blossoming and the birds
are chirping in all the four directions :
*Nandarāni*¹¹ says to her darling son :
"Wake up, oh *Nandakishore* !" ¹²

1 It means "Lord" or a Muhennimedan religious teacher.

2 A Pir.

3 Plural of Nabi(prophet).

4 It ought to be "chauka", which means a square, a courtyard.

5 Rāgas which are to be sung at the link of the night and the day (twilight hour).

6 Shri Krishna.

7 A mark of sandal-wood ointment.

8 One of the names of Shri Krishna.

9 Morning songs are sung in Bhairav, Bibhās, Rāmkali and also in Tōdī ; these melodies are to be sung at the first watch of the day.

10 A fried preparation made from wheat.

11 Yashōdā, the wife of Nanda.

12 Shri Krishṇa, the son of Nanda.

(129) *Rāg Bhairava*(129) *Translation*

Jāgiyē Gōpāla lāla gvāla dvāra thādē ;

Raina andhakāra gayō chandramā
malina bhayō ;
Tārē gaṇa dēkhiyata nahī, taraṇī kiraṇa
badhē ;

Mukulita bhayō kamala jāla,
Bhavara guṇjata puṣpa māla,
Kumudini kumalāni ;
Gandharva guṇa gāna karata,
Snāna dāna nēma dharata,

Harata sakala pāpa ;
Vadata veda vipravānī ;

Bōlata Nanda vāra vāra,
Mukha dēkhi tava kumāra.
Gāyana bhai vāḍī vāra,
Vrindāvana jēvō ;
Jananī kahata uṭhō lāla,
Jānata jiya rajanī tāta,
Sūradāsa prabhu Gōpāla,
Tumakō kachu khēvō.

Wake up, Oh Gōpāla darling, the shepherds are at the door ;
The darkness of the night has gone and the moon has become pale ;
The group of stars is not seen and the young¹ sun's rays are growing intense.
Lotuses are half-closed,
Bees are buzzing on the garland of flowers,
And the water-lily is withering ;
The *gandharvas*² are singing (in praise).
They observe the practices of bath and almsgiving
And thus relieve sins ;
This is what the Vēdas and the Brahmins say ;
Of and on Nandajī says :
"Let me see your face, oh boy !"
It's a long time they have been singing.
In Brindāvana.
Mother asks you to wake up,
The meaning of his line is unintelligible.
Sūradās³ understands thee, a little,
oh Gōpāl.

(130) *Rāgiṇī Bīṇāval, Tāl Tritāl,
Madhya Laya*(130) *Translation*

Sthāyī :

Jāga uṭhē saba jana tuma jāgō,
Gauvana kē charavāla charaīyā ;

Antarā :

Gvāla bāla saba gauvā charāvata,
Tuma re kārana āvata dhāvata,
Sadāranga mana tuma so lāgā.

Wake up ! All have waken up.
The shepherds are taking the cows
(to the woods).

The shepherd's children are feeding
the cows ;
They are running about for you ;
Sadāranga's⁴ heart is set on you.

(131) *Rāg Bhairava, Tāl Tritāl,
Madhya Laya (Medium Rhythm)*(131) *Translation*

Sthāyī :

Jāgō Mōhana pyārē,
Sāvārī suratā morē mana bhāvē,
Sundara lāla hamārē ;

Antarā :

Prāta samē uṭha Bhānūdaya bhayō,
Gvāla bāla saba bhupati thādē,
Darasana kē saba bhūkhē pyasē,
Uṭhiyō Nanda-kishōre.

Wake up, dear *Mohan* !⁵
I am so fond of your dark countenance ;
Our darling is indeed so handsome !

Wake up while it is dawn, and all the
children of the shepherds are awaiting
their lord,
All are pining to have a sight of you.
Wake up, oh son of Nanda !

(132) *Rāgiṇī Kālingdā, Tritāl*(132) *Translation*

Sthāyī :

Aba hōnē lagō prabhāta sakhī,
Bōlata kēkī kira kōkilā,
Kusuma kamala vikaśāta sakhī ;

The day is dawning, oh friend,
The peacock, the parrot and the koel are
singing,
The lotus is blossoming, oh friend !

¹ The morning sun; this refers to the dawn when this melody is recited.

² Celestial musicians.

³ A great devotee of Shri Krishṇa.

⁴ The composer.

⁵ An epithet of Shri Krishṇa.

Antarā :

Aruṇa kiraṇa sakhi pūraba prakāśata,
Bhōra bhayō nisa jāta sakhi.

The crimson rays (of the sun) are glisten-
ing in the east,
The day has dawned and the night is
disappearing, oh friend !

(133) *Rāgiṇī Āsāvārī¹, Tāl Tritāl*

(133) *Translation*

Sthāyī :

Piharavā jāgō jāgō rē,
Jāgō rē, churavā lāgi thāri ghāta ;

Wake up, oh love !
Wake up ; Your favourable opportunity
is being missed ;

Antarā :

Itanamō hī sārī raina bitī.
Chetā pāchhai rāta.

So soon the night has passed away ;
Wake up, it is past mid-night.

(134) *Rāgiṇī Gujari² Tōḍī, Tritāl*

(134) *Translation*

Sthāyī :

Jasodā Hari pālanē jhulāvā³ ;
Halrāvai duralārāvā⁴ malarāvā⁵,
Joi sōi kachhu gavā⁶,
Mērē lāla kō āu nidariyā,
Kāhē na āni suhāvai ;

Jasodā is rocking the cradle of *Hari* ;
She is rocking and patting him.

And is singing him to sleep, that her
darling would soon get sleep,
(To "sleep") "Why don't *you*⁴ find this
hour agreeable ?

Tū kāhai na bēgi sō āvai,
Tākō kānha bulāvā⁵ ;
Kabhā palaka Hari mūda lēta ha⁶,
Kabhā adhara farakāvai
Sovala jāni mauna hvai-hvai,

Why don't you come soon ?

Krishna is calling you !⁵

Now he is closing his eyelids.

And at times he is moving his lips ;
Thinking that he is asleep, she becomes
quiet and calls by signs ;
The heart gets confused,

Hari kari kari saina bulāvai ;
Hī antāra akulāi uthē,
Hari Jsumatī madhurai gāvai ;
Jō sukha Sūra amara muni durlabha,
Sō Nanda bhamini pāvai.

Krishna then sings sweetly to *Jasodā*,
That happiness which is difficult to be
attained even by gods and immortal
*muni*⁶ is attained by the wife of Nanda
(*Jasodā*)

(135) *Rāgiṇī Alhaiyā Bilāvala, Tāl Chautāl*

(135) *Translation*

Sthāyī :

Palanā pala pala gāu pala jhulāu,
Lālana ki subha ghaḍi rē ;

I rock the cradle every moment and sing
him (to sleep),

It is the auspicious day of my darling ;

Antarā :

Agara chandana kā palanā,
Rēśamā⁷ ki dōrā,
Jhulāvata maiyā suhāga bhari.

The cradle is of sandal-wood and of the
wood from the fragrant aloe tree,
The string is silken,
And the *mother*⁸ sings with a heart full
of gladness.

¹ This melody is a pentatonic (ōḍava) one, which avoids "ga" and "rē" (vivādi svaras); it depends on the sentiment of sorrow. *Āsāvārī* is pictured as "longing for her husband, and climbs the Malya mountains; all the snakes desert their sandal trees, and writhe and coil their bodies." (A. Coomarswamy).

² It has the following notes : ṇi rē ga, ma dha ni sā ; sā ni dha ma gā rē sā. This is a variety of *Tōḍī rāgiṇī*.

³ This is one of the lullabies (pōdhāya vē kē pada).

⁴ This is addressed to "sleep" itself; here sleep is personified.

⁵ Holy men.

⁶ It refers to Mother *Jasodā*.

(136) *Rāg Bhairava, Tāl Dādā*(136) *Translation**Sthāyī :*

Jāgō Brija Raja kūvara,
Nanda kē dulārē ;

Wake up, O prince of Brija,¹
The darling son of Nanda ;

Antarā :

Jamunā mē gēda dālē,
Gvāla bāla saba hārē,

You threw the ball in the Jamnā,
The children of the shepherds were all
tired out ;
The snake *Kālī*² hissed,
So śyāma (the blue-coloured) became
so dark.

Kālī phuphukāra dēta,
Shyāma hī cka kārē.

Now we come to a group of rāgas, known as Seasonal (Mausami) Rāgas. Mēgha-Mallāra and its various rāginis are sung in the Monsoon. In these, we find a description of the charm and beauty of the rainy season. Rāgas Vasant, Hindōla and Bahar are sung mostly during the spring and summer ; in these we have the beauty of the spring graphically described. They also depict the enjoyment of spring (vasanta-vihāra) just as Mēgha Rāg manifests the enjoyment of the rainy season (varṣā-vihāra).

(137) *Rāgiṇī Sūr Malhār,³ Tāl Tritāl*(137) *Translation**Sthāyī :*

Bādarvā barasanakō lāgi,
Nanhi nanhi būdana,
Garaja garaja,
Chahu ōra bijari chamakata ;

It has started raining,
It has been drizzling ;
In all the four directions there is lightning
and thunder ;

Antarā :

Kōyalā kī kūka sunata,
Hūka uthata,
Chhatiṇā⁴ qarata ;
Kala na parata,
Piya bina ;
Papihā⁵ piyā piyā⁶ karata

Hearing the voice of the cuckoo,
the heart beats with fear and pain ;
It⁴ is restless without my love ;
And the *papiha* is calling out.

(138) *Rāgiṇī Gauḍa⁷ Mallār, Ektāl*(138) *Translation**Sthāyī :*

Gājē rājē ghana,
Garjata ata barasata,
Druma bēli harakhāta,
Chātaka śikha karata śōra,
Dhana dhana ghana rājē ;

Clouds gather and roar,
There is thunder, and clouds bring a
down-pour,
Trees and creepers are all delighted ;
The voice of the *chātaka*⁸ is heard from
the (mountain) tops,
We are fortunate for having the reign of
clouds ;
The rainbow in the sky looks so beautiful !
Lightning glitters (in the sky),
Rāga Mallārī produces it (lightning),
When it is sung by a guṇi-jana (connois-
seur), says *Haranga*.¹⁰

*Indra-dhamkha*⁹ sōhata nabha,
Dāmini damakata chamakata,
Rāga Mallārī upajata,
Hararanga guṇi ājē.

¹ It refers to Shri Kṛṣṇa. ² A snake, described in Hindu Mythologies.
³ This is one of the varieties of Mallārīkā-Rāgiṇī. Mēgha-Mallār is however regarded as the king of melodies. Sūr-Mallārī has the following notes: nī sā, rē ma, pa ma, nī dha pa, nī sā, nī pa, ma' rē, sā. It is said to have been sung by Sūrdas.
⁴ Heart. ⁵ A sparrow-hawk. ⁶ The call of a sparrow hawk.
⁷ This Rāgiṇī has the following notes: sā rē ma, pa, dha sā; sā nī pa ga ma, rē, ās
⁸ A bird that is said to live merely on rain drops.
⁹ *Indra-dhanuṣa*. ¹⁰ The composer.

(139) *Rāgiṇī Miyā Mallārī*¹

(139) Translation

Sthāyi :

Bōlē rē papiharā,
Aba ghana garajē,
Aba ghana garajē,

The sparrow-hawk is calling out ;
The clouds are thundering,
The clouds are thundering ;

Antarā :

Una ūna kara āi badariyā,
Barasana lāgi Sadārangilē Muhmada
Shāh,
Dāmini-sē kanda chanda,
Mōrā jiyarā larajē.

Little by little, clouds have gathered
themselves ;
They have brought a down-pour, says
*Sadā-Rangilē, Muhamad Shāh*².
Due to the lightning and the thundering
of clouds,
My³ heart is palpitating.

The following three songs are Vasanta mahimā ganā (songs that sing the beauties and enjoyment of spring):

(140) *Rāg Vasant*,⁴ *Tritāl*

(140) Translation

Sthāyi :

Sarasa sugandha naī bana bēli,
Fūla rahī saba bēla chamēli ;

Sweet is the fragrance of the new woods
and creepers,
The plants of *chamēli*⁵ blossom ;

Antarā :

Pavana sugandhita bahata chahu ōra,
Gāya Basanta chatura alabēli.

In all the four directions the scented
wind blows,
Expert belles sing Vasanta (rāg).

(141) *Rāgiṇī Bahār, Tāl Jhumrā*

(141) Translation

Sthāyi :

Bahāra āi rē,
Sakala bana fūlana lāgi,
Kaliyā bēlariyā ;

Spring has set in,
In all the woods there's a blossoming
Of the buds and creeping plants ;

Antarā :

Jēsuvā ambuvā saba fūla rahilā,
Aura āraga saba bēlariyā,
Muhemada Nurē Sēlariyā.

The "tcsu" (flowers) and the mangoes are
in bloom (blossoming),
So are the creeping plants,
So says *Muhemada Nūr Sēlariyā*⁶.

(142) *Rāgiṇī Bahār, Tritāl, Slow
Rythm (Vilambita Laya)*

(142) Translation

Sthāyi :

Naī ṛita naī, fūla, nayē bēla bahāra,
Naī Kaliyana kō nayō rasa ;

A new season, fresh flowers and a bloom
of (blossoming) creepers,
There's a new flavour in the buds ;

¹ This melody is said to have been popularised by Miyā Tānsēn and hence its name. It has the following ascent and descent of notes: Rē ma rē sā, ma rē pa, ni dha, ni sā; sā ni pa, ma pa, ga ma, rē, sa; there were other melodies which have derived their names from Tānsēn.

² He was the last of a series of Mughal kings. He was a great patron of art and hence many a song was composed in his name; he is referred to as Muhamad Shāh Rangilē, (one who is fond of fine arts).

³ This refers to a heroine, separated due to her lover going abroad (Prositapatikā).

⁴ It is one of the seasonal Melodies that sing of the beauty of Spring and its enjoyment (Vasanta-Vihāra). It must have been associated with the celebration of the carnival of spring. The melody is visualised as a dancing Kṛṣṇa.

⁵ An Indian flowering plant.

⁶ It refers to the composer.

Antarā :

Nai drumā nai pāta,
Nai nai ḍariyā,
Tāpara bhavarā bhayō basa.

On the trees, there are new leaves,
And the branches look so fresh ;
On these the bee hovers !

(143) *Rāg Mēgha Mallārī¹, Jhaptāl*(143) *Translation**Sthāyi :*

Umaḍa ghumāḍa mēgha gagana chaḍha āyē :
Bibidha barana sakala, bibidha mana harakhāyā ;

The clouds are gathering in the sky ;

The varied colours of all these enchants the hearts of the wise (learned).

Antarā :

Guniyana karata tāna,
Dha, ga baraja saha gamaka ;
Barakhā rita suhāḍē,
Gambhira sudha mūrata.

Musicians are singing *tānas*,² leaving³
dha and ga and are singing with *gamaka*;⁴
The rainy season is so pleasant, and
*it*⁵ has a pure and serious face.

The following song is set in Sūr-Mallār, it describes the charms of the Monsoon days and the beauty of Shri-Krishna, who has gone to the banks of Jamna. Perhaps this rāga might have been sung by Sūrdās :

(144) *Rāgiṇī Sūr Mallār, Tāl Trītāl (Madhya Laya)*(144) *Translation**Sthāyi :*

Barasana kē bādara kārē ;
Umaḍa ghatū ghana, bijarī chamakē,

The dark clouds shower rain ;
A group of clouds are gathering and the lightning is shining ;

Dina tarvara hariyārē ;

The trees are looking so green during the day ;

Antarā :

Nanda kuvara farajanavā sakhi,
Jamanā taṭa mrigavārē ;
Mōra dharē sringāra sughara ata,
Rāga Mallāra uchārē.

There's the son of Nanda, ch friend,
There are deer on the banks of Jamnā ;
The peacock is adorning himself so beautifully,
*He*⁶ (peacock) sings Rāga Mallāra.

(145) *Rāg Hindōla,¹ Trītāl*(145) *Translation**Sthāyi :*

Hēri māi hēri mā hēri māi hēri mā ;
Barana barana kē basana,
Bhātī bhātī fulavana kē haravā ;
Gūda gūda ḍārū garavā,
Piyā sanga khēlū māi ;

Oh friend, listen oh friend !
Putting on clothes of varied colours ;
And making a garland of various flowers
I shall throw it (garland) on his neck,
So I shall play with my beloved !

Antarā :

Aisō hī basanta fūlyō,
Saba kē manavā hulasānē,
Ata sukha pālō mōrā jiyā,
Piyā sanga khēlū māi.

Such is the afflorescence of Spring,
It pleases all hearts,
My heart is exulted with joy
As I play (Hōri?) with my love.

¹ This Rāga has the following notes; rē ma: rē sā, ṇi pa, ṇi sā, rē, ma rē, pa rē, ma, rē sā.

² Permutations and combinations of notes.

³ These notes are not sung in this Rāg.

⁴ The ten embellishments or graces (gamakādika) of notes.

⁵ The rāga, "it" may also refer to the rainy season.

⁶ The Peacock is said to sing Rāga Mallāra during the rainy season as he enjoys the rain-drops so much ; this follows as a result of the association of this rāga with the Monsoon.

⁷ This also is a seasonal melody ; in spring, in the first watch of the day, its rhythm (swinging movement) is heard.

THE SUBJECT-MATTER OF RAGAS, RAGINIS AND SONGS

The subject-matter is mostly based on stories which are taken from the two epics, the Purāṇas and Kathāsarit-sāgara. The Bhagwat Purāṇa has been the treasure-house of stories, incidents, melodies and sentiments. The Rāmāyaṇa and the Mahābhārata stand next as sources of inspiration.

The group of Bhakti songs is based on (i) the folk religion of the Purāṇas, particularly the Bhāgwat Purāṇa, (ii) on the Bhakti lore inherited from saints all over India, particularly Tulsidās, Sūradāsa and Mīrā, whose songs are popular not only in North India but all over the land, and (iii) the Dharma teachings of different Hindu Sampradayas.

Besides the devotional songs there is another important group of compositions that depicts life, thoughts and sentiments of the Hindus. Herein we have a picture of Hindu social life as viewed from different angles. For instance, there are a few songs relating to married and family life of the Hindus. Thus we have an inkling into the (then-existing) social conditions of cow-herd people and their culture. We have pictures drawn from "essentially Indian life—the home, the village, cowsheds, river-side, ritual and spring festivals, all of which is interpreted in the sense of a spiritual drama."¹

BOOK REVIEWS

A New History of the Marathas. Volume I. Shivaji and His Line (1600-1700). By Govind Sakharam Sardesai, B.A. Pp. 1-374. 5"×8½". One illustration and a map. Phoenix Publications, Karnatak Printing Press, Chira Bazar, Bombay, 1946. Price Rs. 10.

EVER since James Grant Duff wrote his monumental work styled *A History of the Marhattas* generations ago, a genuine need has been felt for placing before the country a connected account of the Maratha people, whose annals have been the subject of long and arduous research on the part of scholars in and outside Mahārāṣṭra. Rao Bahadur Sardesai has, therefore, done well in writing a most useful and interesting history of the Marathas in three volumes, the first of which is the subject of this review. By his simple and strenuous life, his unflinching desire to arrive at truth, and his unrivalled devotion for the cause of the history of his people, Govind Sakharam Sardesai, the octogenarian historian of Mahārāṣṭra, has rightly earned for himself the title of *itihāsa-mārttaṇḍa* (the Sun of History) at the hands of the people. All students of history will agree with him that the results of historical research should be made available in English; and that the great work of the late Viśvanāth Kāśināth Rājwāde and others, remained unrecognised precisely because of its having been written in Marathi. The uniqueness of the history of Mahārāṣṭra does not consist, as the great historian maintains, in that province alone having historical materials which would run into one hundred thousand printed pages, but in some other features of interest and importance which we do not wish to dilate upon here. Whilst it is certainly true that there is a host of materials in the shape of state-papers, *firmāns*, private correspondence, accounts of foreign historians, military regulations and the like, dealing with the history of Mahārāṣṭra in the seventeenth and the eighteenth centuries, it is not correct to affirm that that is the only province which can boast of a proud heritage in the shape of historical materials "unshared by any province of India," (page 2). If we were to judge only by the criterion of printed pages, the history of the non-Maratha royal families of the Deccan has twice the number of historical records to their credit; and modern historians would do well to pause before making exaggerated claims in the matter of historical materials, on behalf of Mahārāṣṭra. What disturbs a modern student of Maratha history is not so much the magnitude of materials as the intensity of communal or national feeling on behalf of royal families and of others, who played such an important part in the history of the land. It is this "extreme form of national pride", as the learned historian rightly points out (page 3), against which we have to be on our guard, especially when we desire to reconstruct the history of the seventeenth and eighteenth centuries. The great historian is, on the whole, free from this prejudice, although occasionally, we may be permitted to remark, he cannot help lapsing into it in spite of himself.

This is perhaps due to his having magnified to some extent the religious tinge that undoubtedly glossed some events, and to the inadequate recognition of the role which the other great Hindu royal families played in the history of the Deccan. When the learned author affirms that "The Hindus in general—the Maratha forming no exception—have during historic times cared more for their religion than for political power," (page 31), one feels that he has overstepped the boundaries of accuracy. How ardently this doyen among Mahārāṣṭrian historians allows himself to be swayed by the religious element is evident when he deals with Shāhji, General Randullah Khan and Shivaji himself.

Shāhji, the father of Shivaji, according to the author, is to be looked upon as the Saviour of the South. "By boldly standing forth to oppose the Mughal Emperor, he (Shāhji) served the cause of the Deccan sultanates and earned their respect and goodwill as a champion of their liberties," (page 64). We do not know how this statement ever came to be written! Granting for argument's sake that the Deccani Sultans felt themselves helpless—which they never did—it can never be said of the rest of the South that in any period of its history it ever looked for any Maratha leader for its political or spiritual salvation! Rao Bahadur Sardesai concludes about Shāhji, thus—"After the extinction of Vijayanagar, Shāhji was the first Hindu leader who could with rapid movements and local knowledge prove a match for the forces of Delhi or Bijapur," (page 84).

We cannot admit this, because there were more intrepid, more generous and more daring military leaders and statesmen in Mysore as well as in Keladi, whose achievements have deservedly won for them an abiding place in the history of Hindu India. Thus, Kanṭhirava Narasa Rāya Oḍeyar of Mysore (1638-1659)—not to speak of his predecessors the gallant Beṭṭada Chāmarāja (1576-1578), and Rāja Oḍeyar (1578-1617),—was compared with “Kṛiṣṇa himself, born to give peace to the world when it was troubled by the Turushkas and resounded with the noise of horse-hoofs.” As for Shāhji's having aided Śrī Ranga Rāya, the last of the prominent rulers of Vijayanagara and thereby helped the cause of the Hindus (page 95),—if we are to place this event in or about 1642 or 1643, as the learned historian would make us believe,—it is impossible to reconcile it with the facts of Vijayanagara history, according to which Śrī Ranga Rāya had just then (1642—43) been placed on the throne of Chandragiri by powerful partisans, who certainly were not in need of the help of Shāhji Bhonsle.

We are afraid that the indefatigable historian has not done any justice to the great House of Vijayanagara nor to the other well-known royal houses of the South, which had so much to do with the rejuvenation of the political and religious life of the South. Why he accepts the unhistorical date 1336 as the year of the foundation of Vijayanagara, the fable of the founders of that kingdom Hahriara and Bukka having been taken as captives to Delhi and converted into Islam, and the myth of Vidyānarya's having helped them to found the kingdom of Vijayanagara (page 27 ff.) as historical facts, when they have no basis in history, cannot be made out. It is certainly not true that the Vijayanagara royal family “continued to drag on a submerged existence in different localities right up to the British conquest of India” (page 29), after the memorable Battle of Rākṣasa Tangaḍi. The connecting links between the Maratha House of Shāhji and that of the great Vijayanagara rulers are not those of Bangalore, Kampili, and Kanakagiri, and the spiritual leader of Śringeri, but other and more permanent ones, which we shall enumerate elsewhere.

Turning to General Randullah Khan, we find that the learned author has the following assertion to make: “Their (i.e., the expeditions led by Shāhji under Randullah Khan) avowed aim was to enhance the glory of Islam by putting down the Hindus, desecrating their temples, and bringing their hoarded wealth to Bijapur,” (page 71). This was not so. For we know from equally reliable sources like those written in Marathi, that due to certain internal troubles in the Keladi kingdom, the petty chieftains of Sode, Bilige, and Basavāpaṭṭana made common cause with the Bijapur Sultan, and accompanied Randullah Khan in his expeditions. Further General Mustafā Khan's expedition, according to the learned author, was victorious (page 75); but according to the Kannaḍa sources, it was a complete failure! Incidentally we may remark, that the author's statement that Shāhji introduced the Mahārāṣṭrian system of revenue administration and accounts in the Kārṇāṭaka regions (page 73), is not borne out by facts which amply show that the time-honoured Hindu system of revenue administration that prevailed in Kārṇāṭaka for centuries before the Marathas were ever heard of as kingdom-builders was, excepting for a few terms, essentially Kannaḍa in nature and genius.

Around the great personality of Shivāji centre a few considerations which may perhaps be briefly mentioned here. First comes the attempt made by the learned author to dwell on the Kṣatriya claims of Shivaji (page 209). He has himself rightly questioned the authenticity of some documents (the *Mudhoḷ firmāns*) about which we were the first to raise some doubts (*vide New Indian Antiquary* for 1939 pp. 6-24); but later on in his work (page 208), Rao Bahadur Sardesai elaborately describes the ceremonies by which Shivāji tried to gain Kṣatriyahood! This is somewhat disquieting. Shivāji is represented as having been the Champion of Hinduism and as an enemy of Islam (pages, 241, 242, 243, 248, 249, 250, 288). But one of the letters written by Shivāji to Maloji Ghorpade of Mudhoḷ in 1677 (pages 232-235) clearly proves that Shivāji's aim was more political than religious! This is substantiated by another letter but written by an English merchant in which we have the important information that Shivāji had “many Muslims in his service and the head of his navy was a Muslim,” and that Shivāji's main grievance was against the policy of conversion either to Islam or to Christianity (page 286). Indeed, the learned historian himself admits that Shivaji was not opposed to the Muslim religion, as he cordially agreed to help Qutb Shah on certain conditions (page 235). In a later context, Rao Bahadur Sardesai confesses that Shivāji was in no way actuated by any hatred towards the Muslims as a sect or towards their religion (page 269). There is no proof that the Hindus of the South ever hailed Shivāji's southern expeditions with all their heart (page 230), nor that he brought into being the institution of eight ministers (page 269), which had long been known in Kārṇāṭaka. In an earlier passage the author confesses that Shivāji did not create this institution (page 105).

We are told that "There is no instance of his (Shivāji's) having plundered innocent people or princes who were not at war with him," (page 282). If that is so, we should like to know why Shivāji swooped on the innocent town of Basrūr in South Kanara in 1664, and, plundering almost all the coastal tracts, sailed back to Gokarna in the same year?

The interesting figure of Rāja Rām affords another example of some statements which are difficult to understand. Why does not the learned author mention the significant fact that, in the course of the flight of that prince, he was sheltered by one of the most well-known queens of Karnāṭaka, who had him escorted to the frontiers of her kingdom? If Shivāji had built a line of strategic forts in the Kāveri valley (pages 323-324), then, why did they not save poor Rāja Rām from despair, and why did they compel him to go across the Ghat regions of Shimgoa, Kaḷasa, and other places, on his way to Jinji?

There are some other points which may be briefly mentioned. Mahārāṣṭra is not a Great *Nation* (page 12), but a Great *Country*; the Mahā Rathis were not Marathas (page 11), but a different people; the well-known Aihole inscription is not dated in the *Christian* year 634 but in the *Saka* year 556, which works out to the year 634-5 A. D.; the same record does not mention the *three* portions of Mahārāṣṭra (*ibid* page, note 2), but simply "the three Mahārāṣṭrakas," which contained 99,000 villages; Ywan Chwang (A. D. 629-645) does not mention the Marathas (page 35), but only the people of the country called Mo-ho-la-ch'a (Mahārāṣṭra), ruled over by king Pu-lo-ki-she (Pulikeś in II); the ancient Rathis were not subdivided into Śātavāhanas, Bhojas, Mauryas, Kadambas, etc. (page 13), but were distinct from all of these, excepting perhaps from the Bhojas between whom and themselves there may have been some affinity; the Bāṇas were not a clan of the Rathis (page 12), but were a family of considerable antiquity, and removed for the Rathis; and the famous deity of Vithoba at Pandharpur was the rallying centre not only in the days of Saint Tukaram (seventeenth century) (pp. 32-33), but centuries earlier when Karnāṭaka monarchs like Someśvara gave munificent gifts to the same (A. D. 1236), and earlier still when it had been installed in the truly liberal and national atmosphere of the Karnāṭaka rulers (Cf. B. A. Saletore, *Antiquity of Pandharpur*, *IHQ*, XI, pp. 771-778). While estimating the work and character of Shivāji, it is not proper that the opinions of modern scholars and contemporary writers should all be jumbled together; historical relevancy requires that the Mughal historian Kāfi Khān, the European traveller Bernier, and the English merchants should have preceded the great scholars of our own days.

The above discrepancies should not blind us to the fact that Rao Bahadur Sardesai has laid us all under a heavy debt of gratitude by writing a great book, and that he has claims to meritorious recognition at the hands of scholars and people alike. His praise is shared by the enterprising Publishers, who have spared no pains to make the volume both attractive and useful, although we cannot help mentioning that the interposing of a page of chronology at the beginning of a chapter is a hinderance from the point of view of studies, and a waste, from that of paper. Its value would be enhanced if it were continued immediately at the end of each chapter.

—B. A. SALETORE

Australia and New Zealand. By T. K. Critchley. Oxford Pamphlets on Indian Affairs, No. 40. Price 6 Annas.

WHEN the need for mutual understanding and co-operation among different nations is paramount, publications of this type which give an idea about every country, its people and problems to the lay reader are to be welcome.

The booklet begins with brief geographical accounts of both the countries to be followed by a discussion of the subjects of population, agriculture, industry, politics and aspects allied to them. The treatise, although brief, enables the reader to obtain a fairly general knowledge of the countries concerned.

A couple of points in the pamphlet deserves special mention. It has been stated that despite attempts by the Government to preserve the Australian natives and improve their conditions, their numbers have been gradually dwindling. The happenings in the past and particularly during the recent years have left doubts about the attitude of the Whites towards the coloured peoples in the minds of few. Similarly, it is hard to agree with the author when he states that there is no scope for Asiatic emigration to these new countries.

The expansion in India's imports from and exports to Australia during the war has been taken to show that both the countries have come closer. It has been indicated that great prospects lie ahead for further expansion of Indo-Australian and Indo-Zealand trade. What is of significance, however, is India's growing adverse balance of trade with Australia, while the latter country has succeeded in changing the character of unfavourable trade balance largely by increasing the exports of processed and manufactured goods. No one will disagree that for mutual benefit India should establish closer trade relationship with the outside world and particularly with her next door neighbours. War has, however, taught our country the dangers of undue reliance on foreign supplies. In the light of this bitter lesson we should strive to be self-sufficient both in the agricultural and industrial sectors, an objective which the author himself sets forth for Australia.

—M. B. DESAI

Location of Industries in India. By Tulsi Ram Sharma. Hind Kitabs Ltd., Bombay. Price Rs. 7-8.

THIS book inquires into an important aspect of the Indian Economy which has hardly received the attention, it deserves. In the first nine chapters, the author examines the location of 8 major industries in this country. They provide excellent illustrations of how in the location of any industry, a delicate and difficult balance has to be achieved among a myriad conflicting factors which are always in a process of constant change. This factual part of the analysis is done with a degree of lucidity, accuracy and careful presentation which are not easily met with in studies of this kind. In the next three chapters, the importance of transport facilities, availability of different types and qualities of labour and prospects of rural industrialisation are discussed in a broad manner. The author points out in his introduction the fundamental weakness of much of what passes in this country as post-war planning—its tendency to be confined to and distorted by our present artificial political boundaries which have little or no economic significance. A discussion of the different and not easily reconcilable objectives which might inspire a replanning of our industrial map is reserved for the last chapter. It is well to realise that a strategic dispersion of industries or avoidance of urban concentration on the ground of its alleged social or moral disadvantages is objects which cannot be placed on a par with others like the transfer of industry to offset the social or structural immobility of labour, diversification of industry to diminish the incidence of sectional unemployment, etc. Apparently, the author is prepared to place his trust in the capacity of the government to make decisions on these and allied matters. If the government limited its efforts to transform the economic geography of the country by a rehaul of its transport system by land, sea and air or by conveyance of electric power to villages and corners of the country, not much difficulty need arise. But outside these general lines of growth, it is difficult to see how a government could overstep these limits without involving itself in interminable responsibilities. The factual analysis of the earlier nine chapters already referred to should serve as a sufficient warning to governments not to undertake responsibilities which are beyond their vision and acumen. The book deserves a close and careful study by all those numerous well-wishers of this country who are engaged in the hectic activity of drawing up all kinds of paper plans for the reshaping of our economic destinies. The publishers deserve to be commended for their enterprise in bringing out a publication at this juncture which has a vital bearing on all post-war planning.

—S. K. MURANJAN

Industrial Capital in India. By M. V. Divatia and H. M. Trivedi. Pp. 91. Tripathi Ltd., Bombay. Price Rs. 5.

THIS book is an important and highly commendable study in the vast and uncharted part of the field of Indian Economics. Ever since formulation of Plans and Targets came into vogue, a number of questions relating to capital resources has confronted the Indian economist. What is the annual volume of savings in this country and how is it actually invested? What are the sources from which they could be augmented? Given particular targets, what is the investment of capital necessary to implement them? The main concern of the authors is to estimate the total volume of capital (in terms of 1938-39 prices) invested in the large scale or organised industry of the country. But incidentally, they provide answers to some of these vital questions as well.

In the case of 10 major industries, two alternative methods are employed. The gross produce and capital employed for a sample of units give a ratio which is then applied

to the whole industry the output of which is on record. Machinery imports over a series of years with appropriate correction for price changes and an assumed rate of depreciation yield the second estimate.

For 6 other major industries the gross output of which is available, the Canadian ratio of Capital to Gross Produce is employed.

These 16 industries cover 55 per cent. of the total factory labour of this country.

For the rest of industries employing the balance of our factory labour, the gross produce is first estimated on the basis of the gross produce per labourer of the aforementioned 16 major industries and then the Canadian Ratio of Capital to Gross Produce is applied to arrive at the capital at charge.

The authors are not unmindful of the conjectural elements involved at each step. The degree of capitalistic methods of production, the hours and shifts in vogue, the duplication in gross produce due to the use by one industry of the output of another, these are only some of the most obvious difficulties of such estimates.

To their estimate of the aggregate total capital in employment in 1938-39, the authors apply three tests. Firstly, this estimate of capital when divided by the net output of industry as conjectured by Dr. Rao gives us a ratio of C/P of about 2 which may be compared with the Canadian 2.30 to 2.45. Secondly, the production function of Prof. Douglas relating to Net Output, Labour and Capital $P = bL^kC^{1-k}$ supplies another check when k is borrowed from the U. S. A. and Canada with a reduction indicated by C/P for the three countries and b is calculated at 12.17 on certain other assumptions. Thirdly, the ratio of capital to gross output is compared for Canada and India—a procedure which is not altogether free from the charge of lack of independence of the statistical values used.

To state in outline the procedure of the estimates and calculations is to set out the enormous difficulties encountered by the authors. They have executed their task with courage and ingenuity. The surprising thing is that the divergences betrayed in the results of alternative methods should be as insignificant as they actually are. It will be the fault of their successors if with the excellent foundations supplied by the authors, they are not able to improve on their pioneer workmanship and constructive skill.

—S. K. MURANJAN

Social Security. By N. A. Sarma. National Information and Publications Limited, Bombay, 1947. Price Rs. 2-4.

ON 6th November 1946, the Workmen's State Insurance Bill, one of the most important legal enactments of labour interest, was introduced, almost without any publicity, in the Central Legislative Assembly. The Bill should have received some publicity not only because of its importance as an advanced step in the field of Indian Labour Legislation, but also in view of the necessity for some propaganda to ensure the success of its working. The failure of the Government in this respect can, however, be compensated, though partly, by publications on this subject. Mr. Sharma's "Social Security," is a timely publication for getting the public opinion focussed on an important labour problem.

What strikes one on going through the book is the up-to-date treatment of the subject undertaken. Too often we come across references to recent events such as the Wagner-Murray-Dingell Bill (p. 15), the National Social Security Plan of some members of the British Liberal Party (p. 21), Income Security Recommendation of the I. L. O. (p. 22), British National Insurance Bill (p. 24), and a National Health Service of U. K. (p. 57). About India too, such references to Workmen's Compensation (Amendment) Act, 1946, (p. 38), to Workmen's State Insurance Bill (pp. 46 and 64) and to Bhore Committee Report (p. 62) are not uncommon. The Bibliography at the end too consists mostly of recent publications. In one place, however, the author seems to have probed into the future, when he remarks, "The Labour Investigation Committee of the Government of India has recommended the standardisation of occupational nomenclature and wages in the various industries and units in the same centre of an industry" (p. 40). This sentence was written sometime before January, 1947, whereas the Main Report of the Labour Investigation Committee was published only four months later,

The treatment of the subject, though up-to-date, seems to be one-sided ; the financial aspect of social security has received too much attention. Other important aspects of the problem, such as the administration of the Fund, the medical organisation, scope of the legislation, benefits to be given and the judicial machinery have been either hurriedly discussed or altogether omitted. The Workmen's State Insurance Bill is a compulsory state insurance measure, providing for certain benefits in the event of sickness, maternity and employment injury to workmen employed in or in connection with work in perennial factories. The administration of the scheme is to be entrusted to an autonomous Corporation constituted by central legislation. Various interests are to be represented in the executive body of the Corporation. The Fund will be mainly derived from contributions from employers and workmen and the benefits given will be for sickness, maternity and employment injury. Medical care and treatment will be provided by Provincial Governments. Workmen's State Insurance Courts will decide disputes and adjudicate on claims. All these provisions of the Bill deserve a close and critical study and a book on Indian Social Security should examine why the Government of India have chosen a particular line and having chosen that why have they placed a limit at a particular point. Why the Bill was modelled on similar legislation existing in Chile, Venezuela and Bulgaria, and not on that of more advanced countries like U. K. and U. S. A. ? A review of how far the Bill carries out the principles embodied in the Conventions and Recommendations of the International Labour Conference (as given in *International Labour Code*, Articles 464-608) may also prove useful.

Another defect of the book is in abundance of quotations. Especially in the first two chapters, lengthy quotations have been often found to have been linked by a sentence or two of the author.

On the whole, however, Mr. Sarma's book is a useful addition to Indian labour literature. It is perhaps the only book on social security problems in India published after the publication of the Workmen's State Insurance Bill. Replying to a cut motion, the Labour Member of the Government of India said on March 11, 1947, that an officer has already been detailed to study the questions relating to unemployment, old age and retirement pensions. Let us hope publications like the one under review will take note of all such problems of social security in India.

—S. D. P.

A Socio-Economic Survey of Weaving Communities in Sholapur. By Dr. R. G. Kakade, M. A., Ph. D. Pp. 221. Publication No. 14 of the Gokhale Institute of Politics and Economics, Poona. Price Rs. 10.

THE book under review is a part of the work of the Gokhale Institute which made a socio-economic survey of Sholapur on the lines of its Poona Survey. It is needless to mention that urban surveys of this kind have never been even thought of in our country. Neither our universities nor even our great municipalities and corporations have ever felt the need for comprehensive urban surveys. They have not even attempted any exhaustive enquiry of any urban community or craft. Apart from the Labour Departments' enquiries, there are of course some urban studies; but many of them are either scrappy or so highly specialised that their scope is limited. Comprehensive surveys of the type published by the Institute are yet a desideratum. This can be easily understood if only we care to note what distinguishes the Gokhale Institute from our Universities in regard to their aim and the ambitions of men who guide them.

The Institute was started with a purpose quite different from that of Economic Departments of our Universities. It is not interested in the mass production of post graduates nor in stimulating what now passes for "academic studies." It is primarily a research institute. It has been the ambition of its Founder-Director to make it a centre for the study of practical economic problems crying for a solution. It seeks to avoid the traditions and lopsided development of economic studies in our Universities and to direct researches to a more fruitful social purpose. Without any disregard for theoretical and abstract studies which are recognised as indispensable, the organisation of researches in the Institute has stressed the necessity for and therefore has concentrated on the collection of factual data based on scientific field investigations with a view to supplementing the numerous published statistics which are known to be extremely unsatisfactory, for it is recognised that such data alone could give an indication of the lines of policies that administrations should adopt. The importance of this kind of work in an age of planning can hardly be exaggerated.

During the 15 years of its existence, the Institute with a handful of men and slender resources but with enormous public goodwill (which it has rightly capitalised) had undertaken very useful researches and published many monographs which have set a pattern for research in social sciences in India to-day. All of them have a distinctiveness of their own. How the spirit and the traditions of the Institute are completely imbibed by Dr. Kakade, once its student, is revealed in the book under review. "*The Socio-Economic Survey of Weaving Communities in Sholapur*" is so comprehensive that no aspect of the communities' life or of the industry on which they depend is lost sight of. Nor is there any defect in the method adopted in collecting or presenting the mass of data incorporated in the book. The extra care that Dr. Kakade has taken in acknowledging the sources of his information is a testimony to his integrity as a research student. Nor is there anything to be desired in the manner of presentation. The results of his intensive studies of the economics of 107 weaving establishments and the conditions of 541 weaving families belonging to different economic strata are neatly presented in 63 tables, each emphasising a single fact and being inserted in its appropriate place; this is a mark of his craftsmanship. Further, the chief merit of Dr. Kakade's book is that to which Principal D. R. Gadgil in his foreword draws the reader's attention. He writes: "Dr. Kakade has not been content with presenting a static picture; he attempts to trace past history and to evaluate future trends. Even more important than his dynamic view is the integration of the economic problem with its social setting." Dr. Kakade shows how the industry has been adapting itself to the changing conditions and the workers have not been either slow to react to them.

The title of the book, it appears, is slightly deceptive for it does not specifically mention that it is primarily concerned with the weaving communities engaged in the handloom industry. Sholapur is more known as a centre of mill industry to many than as a centre of handweaving. One will naturally expect from the title of the book that it would deal with the economic and social conditions of some 20,000 workers employed in the five mills in Sholapur. Further, since more than half the book is devoted to the study of the organisation etc. of the handloom industry, one feels that a title like "*A Socio-Economic Survey of Handloom Industry and Handweavers of Sholapur*" would have been perhaps more appropriate. But this does not in the least detract anything from the value of the book.

Now to a brief review of the contents of the book. It comprises nine chapters; and it could have been divided into two parts: Economic and Social. The first chapter deals with the "history of the handloom industry" in Sholapur. The subsequent three chapters describe "the raw materials and processes," the "size and structure of the industry," and the "associations" of different interests in the industry. A detailed picture of its organisational structure is given in chapter III. The constructive lines of "reform and reconstruction of the industry" are indicated in Ch. V. While much familiar ground is covered there is a freshness in regard to many suggestions made, for instance, regional marketing survey. The latter part of the book comprising the last four chapters deals with the most numerous of the weaving communities in Sholapur viz., the Padmasalis. Their "social and economic conditions," their "ethnology, mythology and religion," and, their "communal life" are described. This is followed by suggestions for the improvement of their conditions of life.

Chapters III and VI in particular contain very useful information. The latter deals with the migration of the Padmasalis, (the most important weaving community in Sholapur), the size, age, sex, composition of their families, the economic status of earners, the extent of desertion of the traditional occupational, the earnings of the families, their standards of food and other articles of consumption, their indebtedness and a number of other questions. Several constructive suggestions are made for removing ignorance, illiteracy, poverty, indebtedness and malnutrition which afflict the community. The introduction of a minimum wage, the extension of the provisions of *danduyet* to debts incurred in the Nizam State, the establishment of a development trust for the construction of houses in the weavers' colony are some of the measures recommended by the author.

Corresponding to this detailed investigation of the economic and social conditions of the weaving community there is in Chapter III a detailed study of the structure and organisation of the handloom industry in Sholapur. It deals with the size of production units, the economic status of different persons employed (independent artisan, *asamior karkhanadar*), the character and composition of labour employed, the technical structure of the industry indicating the volume of capital required and the sources from which it is obtained, the marketing structure relating to the purchase of materials at raw

one end and to the organisation of the sale of finished products at the other, the composition of production on the handloom and the structure and extent of the markets consuming different products, and the range and growth of mill competition. All these are reviewed with a view to indicating the defects of the industry which affect the incomes of the weavers as well as the forces that play for the survival and progress of the industry on which depend the prosperity of several millions of weavers in the indigenous industry all over the country.

After reviewing the efforts made in the past by Government and other agencies to assist the industry and the weaver, the author discusses the proposals for the future (Ch. V). The question of the mill-handloom competition is naturally the first to receive attention. He advocates the adoption of a policy of discriminating protection to the industry which should, without restricting mill production, encourage the handloom industry partly through a subsidy to it on the basis of its production and partly through a duty on a mill-made cloth. Not contented with a negative policy he desires that the industry should be reorganised with a view to increasing its efficiency, reducing its cost of production and improving its competitive power. While none but romantics would resist technical and organisational improvements in handicrafts and their being replaced by mechanised factory production if need be (which would benefit the community as a whole) it is imperative to warn against the tradition of discriminating protection in this country and the dichotomy of consumers *v* producers, taxpayer *v* producer etc. Both of them have been employed by vested interests in a way not helpful to the class which needs protection most urgently. The criterion of a creative policy of protection is employment and not reduction in costs alone. We should not make a fetish of costs and efficiency. Our problem is one of providing employment and a measure of economic security to all. The handloom industry along with a number of handicrafts offers scope for employment without reducing the level of national output. It would be shortsightedness to allow unrestricted mill competition. If the critics of the handloom have no alternative to offer to those who are ground by poverty and unemployment except an illusory paradise under industrialised India; they cannot then cry down the handweaving industry as archaic and its protection as a cult of incompetence. The philosophy of protection is certainly more comprehensive than measuring everything in terms costs and prices. As a tool of policy it does not seek to perpetuate "go-slow" nor to veto technical advancement, but it certainly seeks to prevent the burden of adaptations inevitable in a continuously progressing community from being entirely thrown on that section of the society which can least afford to bear it. This is the thesis of Dr. Kakade if I understand him properly.

Dr. Kakade's book is welcome, for at a time when our Provincial Governments and the Central Administration are talking about economic planning and are anxious to give the rightful place to handicraft it has a special significance.

—K. S. VENKATRAMAN

LIST OF THESES

Table showing M.A. and Ph.D. Graduates in History, Economics and Sociology from 1st January 1947 to 30th June 1947, with the titles of their theses, etc.

Name of the Candidate	Subject of the Thesis	Name of the Professor under whom the Candidate Worked	Name of the Institution
	M.A. <i>Economics</i>		
Kapasi, C. B.	The Economic Development of the Baroda State	Professor D. R. Samant	U. E. S.
	<i>Sociology</i>		
Kanal, U. R. (Miss)	The Customs and Manners of Central Punjab	Dr. G. S. Ghurye	U. E. S.
	Ph.D. <i>History</i>		
Virji, K. J. (Miss)	The Maitrakas of Valabhi	Professor G. M. Moraes	St. X.
	<i>Economics</i>		
Patel, G. D.	The Land Settlement in Gujarat under the British	Professor D. R. Gadgil	G. I. P. E.
Raman Rao, A. V.	An Economic History of the Andhra Districts (1766-1865)	Professor D. R. Gadgil	G. I. P. E.
	<i>Sociology</i>		
Hate, C. A. (Mrs.)	Social Position of Hindu Women	Dr. G. S. Ghurye	U. E. S.
Sethna, M. J.	Society and the Criminal with special reference to Problems of Crime and its Prevention, Prison Reforms and Juvenile Delinquency	Dr. N. A. Thoothi	U. E. S.

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HYMNS TO INDRA IN MAṆḌALA VIII

(Nos. 76-78; 80-82; 88-93; 95-100)

By H. D. VELANKAR,
Wilson College, Bombay

76

(1) LIKE the Leader of the Maruts (i.e., Indra himself), I invite this wise Indra who rules with his might for the subjugation of foes. (2) This Indra, the friend of the Maruts, broke to pieces Vṛtra's head with his Vajra furnished with a hundred joints. (3) Growing powerful, this friend of the Maruts has blown off Vṛtra, releasing the waters of the (aerial) ocean. (4) This surely is that Indra, by whom this sun's light was conquered with the help of the Maruts, for the draught of Soma. (5) We invite with our hymns this mighty, impetuous, straightforward Indra, who is accompanied by the Maruts. (6) We invite Indra, the leader of the Maruts with this ancient hymn, for the drinking of Soma. (7) Accompanied by the Maruts, drink Soma at this sacrifice, oh oft-praised liberal Indra of a hundred powers. (8) To you, the Lord of the Maruts, alone are these pressed juices offered with devotion, together with the hymns, oh Indra, lord of the Adri. (9) Sharpening your Vajra with might, drink this pressed Soma as the leader of the Maruts, oh Indra, at the sacrifices. (10) Standing up mightily (for an exploit), you have moved your jaws after drinking the Soma pressed out in the jars, together with (the Maruts). (11) Both the worlds piteously cried out to you (for mercy), while you were crushing down the Dasyu when you killed him. (12) Beginning from Indra (i.e., his top), I have measured around (the whole of) his body this holy prayer of mine, having eight feet and nine sides.

76

(1)c : *na* is a particle of comparison. A comparison of Indra with himself as the lord of the Maruts is meant. The poet's thoughts may be explained as follows :—He first invites Indra (*imam mīyinaṁ indram*), whom he next compares with the chief guest of the hymn i.e., Indra Marutvan, the point of comparison being *vṛṇjase* "subjugation of the enemies". At X. 21.1 we find a similar situation in connection with Agni; Agni as the Hotā is compared with Agni as the deity, who is then praised in the rest of the hymn, as Indra Marutvan is praised here in vv. 2-9. The transition from Indra to Indra Marutvan in one case and from Agni the hotā, to Agni the Deity in the other is secured through the medium of a comparison. A similar transition through a comparison for the sake of praise is already seen at VIII 70. 2-4 (in v. 2*cd* and 3*ab* the poet praises the Vajra; in v. 3*cd* he compares this Vajra with Indra and then immediately proceeds to praise Indra). (2) *vṛtrasya śiraḥ* : See on VIII. 6.6. (3) *śamudra* may even be the earthly ocean; "waters belonging to i.e., having as their goal, the ocean"; cf. IV. 16.7; VII. 87. 1; IX. 62.26 etc., (8) *hrdā*: Inward sincere feelings of love and friendship are implied by this word which is usually associated with the word *manasā*. (9) *vajram śiśānah*: Cf. I. 54.4; 55.1; 130.4; VII. 104. 19; VIII. 15.7. (10) *śuḥa* i.e., *marudbhiḥ saha. camū sutam* : See on VIII 4.4. (11) *krakṣamānam*: cf. *ava krakṣam* VIII. 1.2. *akṛpētām*: Because of the very fierce form which you assumed when killing the Dasyu. Cf. V. 83.2. (12) *pari* goes with *tanvam*; *indrāt tanvam pari*: "Beginning from Indra, right round the whole of his body"; i.e., beginning from his crown and ending with the tips of his toes! The *aṣṭapadī navasakti vāk* (hymn having feet consisting of 8 letters and spread over 9 sides) very likely refers to vv. 1-9 in the Gāyatri metre, where Indra Marutvan, the chief guest of the feast, is praised.

77

(1) Soon after he was born, Śatakratu thus asked his mother : "Who are fierce? who are known as such?" (2) Immediately then, Śavaśi mentioned Aurnavābha and Ahīśu (and said) : "These, oh son, may be the overpowerers". (3) The slayer of Vṛtra did surely press them down together with his hammer (i.e., the Vajra), like the spokes in the hole (of the axle). The killer of the Dasyus became exceedingly powerful. (4) In a single round Indra drank all the three hundred deep tanks of Soma together! (5) Right in the bottomless regions Indra smashed to pieces that Gandharva, in order that the priests may prosper. (6) He pierced (the boar) from the mountain heights; he put the cooked food (in the udders of the cows). Indra (held in his hand) the well-stretched arrow. (7) Your arrow, whom you made your companion, is matchless, decorated with a hundred stars and furnished with a thousand feathers. (8) With that (arrow) bring (food) to your singers, in order that they may eat it, and also to their men and women, oh god firm and skilful, becoming so in an instant. (9) These are the noblest deeds performed by you in their fulness. You have supported the strong places with all your heart. (10) The widely striding Viṣṇu being urged on by you, brought all these (things) for you, namely, a hundred buffalos and the meal cooked with milk; (but) Indra himself brought the robber boar (whom he had killed). (11) Your bow is well fashioned, mighty and the bringer of happiness (to your bards). Your arrow is golden and lovely. Both your arms are attractive and very well fashioned; they are the multipliers of Soma to you who are the drinker of the sweet.

78

(1) Bring us Purodāśa, oh Indra, a thousand (libations) of the intoxicating Soma and hundreds of cows, oh brave god. (2) Bring us

77

(1-2) Cf. VIII. 45.4-5. *abravīt* with a double meaning "mentioned" and "said" (to be supplied in *c*). *santu*: "They are heard as fierce and may be regarded as such as long as Indra's superior might is not known". (3) *kheḍā* (from *khid*) is the Vajra; cf. VIII. 72.8. (4) *pratidhā*: "round, turn, shift." *trīṇi śatā*: Elsewhere only three are mentioned; cf. V. 29. 7-8; VI. 17.11; VIII. 7.10. *kāṇukā*: Adj. of *sarāṇisi*; it either means "deep, capacious so as to contain large quantities" (from *kaṇ* to bore as in *kāṇa* X. 155. 1), or "tempting, inviting" (from *kaṇ* to love, induce etc.). (5) Gandharva is Śuṣṇa as at VIII. 1.11. *brahmabhyāḥ vṛdhe*: Two datives; one of person and another of purpose. (6) The object of *avidhyat* in *a* is the *emuṣa varāha* in v. 10 below; cf. I. 61.7; also VIII. 92.2ab. *pakvaṃ odanam* is cow's milk, the same as *kṣīraṇākam odanam* in v. 10. With the help of it Viṣṇu prepared the Soma for Indra; cf. II. 22.1; VI. 17.11; X. 113.2. In *c* supply *ādade* (cf. VIII. 45.4) or *adhārayat* from *b*. It would appear that before he went to kill Vṛtra, Indra first killed a big boar, then a hundred buffalos and next put milk in the udder of the cows for his Soma, thus completing the preparations for his great meal. Agni then came forth and cooked the animals, while Viṣṇu took the cooked food namely, the milk and prepared a large amount of Soma for him. (7) *śatabradīna*: *bradhīna* is a bright spot, a star with which weapons and shields are decorated. (8) Supply *odanam*, as an object of *ā bhara* from v. 6. *sadyo jātaḥ* is to be construed with the vocative changed to nominative for this purpose. (9) *parīṇasā*: Adverbially used instrumental of *parīṇas* "fulness". *vidu* "strong places like heaven and earth". (10) *viśvā tā* refers to all things mentioned in *c*; in *d* supply *abharat*. In *abc* Viṣṇu is the subject, while in *d* it is Indra. As we know from other passages like V. 29. 7-8, Agni cooked the buffalos and Viṣṇu prepared the Soma for Indra; but the *varāha* was killed and brought by Indra himself to the place of the meal. Perhaps it is suggested that it was too big to be cooked by Agni or brought by Viṣṇu and so it was brought by Indra himself and eaten raw. (11) Mark the contrast between *twikṣam* and *sūmayam*. *ṛdu* is the soft drink and *ṛdubā* is Indra.

78

(1) *purodāśam*: The poet requests Indra here as at VIII. 2.11, to help him to procure sufficient corn, Soma shoots and cows which are needed for preparing the offerings and Soma libations required to be offered to him. (2) *hiranyayā*: Instrum. of *hiranyayā*

ornaments, cows, horses and ointments together with the golden thought. (3) And bring us many things which adorn the ears, oh bold god. For, you are heard far and wide. (4) No one is the furtherer of your worshipper, nor a great winner, nor a liberal giver for him;—none indeed oh brave god, other than yourself. (5) Indra can never be overthrown, nor can the mighty one be overpowered. He hears all and sees it (too). (6) The undecieved Indra carefully observes devotion and zeal of men—observes it before censure ! (7) The belly of the victorious Disposer, who kills the foes and drinks the Soma, is completely filled with mental power ! (8) All treasures and fortunes which are unhampered and easy to give are well collected in you, oh Soma. (9) My desire longing for corn, cows, gold and horses approaches you and you alone. (10) With a hope fixed on you do I hold in my hand even a scythe. Fill me with corn, whether reaped or collected, by your (large) fist.

80

(1) I have not made any other god my sympathizer, oh Indra of a hundred powers ; do take pity on us. (2) Do take pity on us, oh Indra, who being kind to us have favoured us before, for winning the prize. (3) Why indeed are you the defender of the presser of the Soma and the inspirer of the meek ? Would you not help us well, oh Indra ? (4) Defend our chariot, oh Indra ; lead to the forefront this chariot of mine even when it is lagging behind. (5) Why indeed do you sit indifferent ? Lead our chariot to the first rank. (Grant us) best fame which seeks the prize. (6) Protect our prize-seeking chariot; it is easy for you. What is in the way ? Make us the easy winners (of the prize). (7) Harden up Indra ; you are an iron fort. This blissful and pious hymn of mine goes to your appointed place. (8) Do not apportion failure to it; the race-course is vast and the prize is (already) laid down.

(irreg. for *hiranyayī*). The thought (*manā*) is called "golden" owing to its association with *cyāñjana*, which is golden; cf. *hiranyayam añji* at VIII. 29.1. V. 1 enumerates things which are needed for worshipping the deity, while v. 2 mentions those that are required for personal enjoyment and enlightenment. (3) *karnaśobhanā*: Supply *śratāñsi*; acts or possessions which gratify the ear (*śrutya* or *śravāyā*) are meant. Or perhaps, ear-ornaments are intended. In *c* supply *vasuḥ* from the vocative. (6) *manyu* is the "zeal" cf. VII. 61.1; also V. 66.4. *purā nidah* "in spite of, or before the rivals' censure". *vidhataḥ* used of the deity as at VI. 3.7. Usually it is used of a worshipper. (7) *kratvaḥ pūnam*: cf. *yavasya pūrdhi* v. 10 (gene. for instrum.); *kratu* is mental power here identified with Soma which gives it and which Indra is asked to drink (*somapānnaḥ*). It is really the Soma drunk by Indra which brings rich gifts and fortunes to the worshipper. This thought is foremost in the mind of the poet when he has completed v. 7; so suddenly he addresses Soma instead of Indra in v. 8, extolling his greatness. In v. 9 however, he reverts to Indra. *sudātu* like *suhanu* (VII. 19.4; 30.2) is either adverb or nom. (or accu.) plural. (10) Cf. v. 1-2 above. *tava āśasā*: Cf. IV. 5.11; also see V. 32.11; VIII. 24.11; 66. 21. *dīna* from *dā* to cut; cf. *dātra*.

80

(1) *baḍā*: Instrumental of *baḍ* (from *bah* "to be firm"), which is a particle of emphasis, adverbially used. (3) "Why are you called the inspirer of the meek and the defender of the priest, if you do not inspire and defend us?" (4) The hymn is a prayer to Indra to bring success in a chariot-race which is about to begin; cf. vv. 4-6 and 8. (6) *c*: cf. I. 17.7c. (7) *a*: Cf. III.30. 15a; VIII 24. 10c. *pūrasi*: Cf. VII. 15.4; 95.1; I. 189.2. *bhadrā* goes with *dhiḥ*; cf. III. 39.2c. (8) *śim* refers to *dhi* in v. 7.; *c* is doubtful. It probably refers to something pertaining to a horse-race. Aratnis are perhaps some fence-like contrivances for the protection of the race ground, which are removed at the time of the actual race. Aratni in the sense of "fence or prison" occurs at X. 160.4. It is

The bow-like fences (of the race-course) are removed. (9) We long for that, namely, that you make a sacrificial fourth name for yourself. Immediately then you shall proudly declare yourself as our lord. (10) Oh immortal gods and goddesses whosoever are here, Ekadyu has glorified and gladdened you. Bestow on him a praiseworthy gift. May god Indra whose treasure consists of hymns, go quickly to him in the morning.

81

(1) Seize with your right hand, being possessed of a capacious hand, that brilliant loot rich in food, for our sake, oh Indra. (2) We know you by means of your favours, as the performer of many (brave) deeds, the giver of many gifts, the lord of many treasures and possessed of vast dimensions. (3) For, neither gods nor mortals are able to obstruct you who resemble a fierce bull, when you want to give, oh brave one. (4) Approach Indra; let us praise that self-shining lord of wealth. May he not harm us in respect of his gifts. (5) May he praise aloud; may he sing and hear the Sāman which is being sung. May he mutter his consent with a gift. (6) Bring us (wealth) with your right hand. Seize it firmly with the left. Do not exclude us from a share in your wealth. (7) Step forward; bring boldly to our men, oh bold god, the wealth of a worse niggard. (8) Whenever any treasure is to be won by you in the company of your singers, conquer it well in our company. (9) Your treasures which are all-pleasing, immediately hasten to us and quickly agree well with our desires.

82

(1) Run towards us from far or near, oh Vṛtra-killer, when an offering of the sweet Soma is brought to you. (2) The Soma juices are sharp; do come. The pressed juices are intoxicating. Drink boldly as you are accustomed to do. (3) Be delighted with (this) food; may it be immediately in keeping with your choice and fury and agreeable to your heart. (4) Do come, oh god without foes; you are called down to these hymns (from your home) in the bright highest firmament of the heaven. (5) This Soma, which is pressed by the stones and cooked up with milk, is offered to you for your wild joy, oh Indra. (6) Carefully hear my call, Indra; enjoy a draught with satisfaction of our pressed juice mixed with cow's milk. (7) Do drink of this Soma which is pressed out in cups and jars for you. You are its lord. (8) Do drink

assigned (as a punishment), to a non-presser of Soma, by Indra. (9) *turiyam nāma yajñīyam*: Cf. *turiyam uktham* X. 67. 1; *turiyam brahma* V. 40. 12. The significance of *turiyam* is not very clear. In any case, it seems to refer to what is uncommon or unusual, three names or hymns being supposed to be lying within the range of ordinary circumstances.

81

(1) *grābham*: "What is seized, loot". Supply *hastena* from *mahāhastī* in *c*; cf. X. 180. 1c. (3) *bhīman gām*: The common property in the simile is *na vārayante*: cf. VII. 19.1; X. 103.1; also V. 56.3d. (4) *stavāma* begins a new sentence as is seen from the accent. *rādhāsā mardhīṣat*: At III. 54.21c the locative *sakhye* and at VI. 23. 9d, the dative *avase* is used with the same root, in the same sense. (5) Indra is the subject; see on IV. 16.3. (9) *jarante*: "sing in consonance with i.e., are proportionate to (our *vaśa* i.e., desires)."

82

(1) Construe *madhvaḥ* with *bharmaṇi* and *prati* with *drava*. (2) *dadhyḥ piba*: "Drink without shyness or reserve"; cf. I. 23.1. (3) *varāya* is same as *varam ā. manyu* is "spirit, fury"; cf. VIII. 84.4. (4) *ā* repeated in *a* as at VIII. 1.16. *ca* and *ni* (here on earth) in *b* show that *hūyase* is to be supplied in *c*. (8) *apsu candramā īva*: The reddish brown orb of the

of this Soma which looks like the moon in the waters when it rests in the cups. You are its lord. (9) Do drink of this Soma which the hawk has brought for you in his claws, across the regions (of the heaven), and which cannot be forced out (from its adopted place). You are its lord.

(1) We greet with our songs that your wonderful Indra, who repels an attack and takes delight in the heavenly intoxicant, as the cows greet their calf at the stables. (2) We pray to Indra, who dwells in heaven, who is very liberal and surrounded by powers, and who feeds many like the mountain, quickly to send a loot consisting of food, hundredfold and thousandfold, and accompanied by cows. (3) Even the great and strong mountains cannot oppose you, oh Indra. None can obstruct that act of yours when you want to give wealth to a singer like me. (4) A fighter as you are, you overpower all creatures by your wisdom, strength, wonderful powers and greatness. This hymn which the Gotamas have produced turns you hereward for protection. (5) For, you have grown far beyond the very ends of the heaven by means of your vigour. The earth's regions have not been able to contain you, oh Indra ; you grow as much as you will. (6) None is an opponent of your gift which you would give to your worshipper. Be the inspirer of our hymn, great as you are, that we may win loot.

89

(1) Sing your mighty hymn to Indra, oh Maruts, which is the greatest killer of the Vṛtras and by which (you) the holy gods recovered the divine ever-watchful light, for the sake of this god. (2) The destroyer of curses has blown off the curses (of the enemies) ; and then did Indra become glorious. The gods submitted themselves to your friendship, oh Indra possessed of mighty light and followed by the host of the Maruts. (3) Sing your song to the great Indra, oh Maruts ; may the killer of Vṛtra possessed of a hundred powers kill the enemy with his Vajra which is furnished with a hundred joints. (4) Bring down (your Vajra) boldly, oh bold-spirited Indra ; may your glory be great. Let the motherly waters flow forth with speed in spite of him (i.e., Vṛtra). May you kill Vṛtra ; do win back the sun's light. (5) Since you were born for killing Vṛtra, oh matchless Maghavan, so you broadened the earth and propped up the heaven. (6) So was the sacrifice born for you, so the hymn and the Haskṛti. So have you been the overpowerer of all that is born

rising moon touching the waters of the ocean is meant. (9) For Soma and Śyena, cf. III. 43.7; IV. 18. 13; 26. 1ff; VIII. 100. 8; IX. 68.6; 77.2; X. 11.4; 144.5 etc.

88

(1) For the simile, cf. I. 3. 8c. (2)b : Cf. VIII. 49.2cd. (3) *ab* refers to Indra's deeds of bravery; *cd* to his liberal gifts. For the former, cf. III. 32.9; 16; IV. 31.9; 42.6; V. 32.9; VIII. 66.2; for the latter, cf. v. 6 below and IV. 30.23; 31.9; 32.8; VII. 32.5; VIII. 24. 5; 28.4; IX. 61. 27. (5) Cf. III. 36.4; VII. 21.6; VIII. 6.15; 12.24.

89

(1) The Maruts are addressed in *ab*; they are meant by *ṛtaṛdhah* in *c* and the reference is to the killing of Vṛtra and Vala and winning back of the waters and the luminaries; cf. vv. 3-4. *devam jyotiṣ* is the Sun and *devāya* is *indrāya*. (2) The Maruts are meant by *devāḥ* in *c*. (4) Supply *vajram* as the object in *a* and compare II. 30.3; also I. 32.9. *vi arṣantu* i.e., *vi vṛtram arṣantu*; cf. note on *vi dṛdhā* at VI. 17.6 and 30.4. *jaya*: Imperative of the imaginary past. (6) This verse continues the narration of the effects of his being born with a definite purpose; *haskṛti* is some part of a sacrificial hymn; Agni is

and all that is yet to be born. (7) You have sent the cooked food to the uncooked (cows) : you have made the Sun ascend in the heaven, oh Indra. Heat up, like this Gharman, oh bards, a mighty hymn which is very dear to this lover of hymns, by means of your well composed hymns.

90

(1) May Indra who deserves to be invoked in all battles come to our help. (May he come to) our prayers and libations, being the killer of Vṛtra, a great conqueror and one who deserves any praise. (2) You are the foremost giver of gifts ; you are the unfailing ruler. We seek the friendships of the great and mightily glorious son of strength (i.e., Indra). (3) These hymns which do not contain much that is unusual, are composed for you, oh Indra lover of hymns. Accept these as mediators, oh Indra which we have composed, oh lord of the bay coloured horses. (4) For, as a reliable warrior you overthrow many enemies, being always unbent, oh Maghavan. Such as you are, bring wealth towards your worshipper, oh mightiest wielder of the Vajra. (5) You are far-famed and impetuous, oh Indra lord of strength. You all alone kill matchless and invincible enemies with your (Vajra) which is the supporter of men. (6) Now we ask you, the wise one, for a gift as though it were our share, oh Asura. Your protection is like a spacious hide, oh Indra ; may your favours pervade us.

91

(1) A certain girl, while going down to the river, found Soma on the way. While bringing it home, she said (to the Soma) : Let me press

called *haskartā* of all sacrifices at IV. 7.3. Perhaps *haskṛti* means "cheering up, encouragement." (7) *āmāsu pakvam*: Cf. I. 62.9 and note on II. 17.6. b: cf. I. 7.3; 51.4; IX. 86.22; 107.7; X. 156.4. *sāman* is accu; *gharmam* is the Upamāna and *tapata* is the common property. The correspondence assumed by Oldenberg between *ab* on the one hand and *c* on the other does not seem to be correct in view of the particle of comparison *na* in the latter. Br̥hat (Sāman) is already mentioned as being sung by the Maruts in v. 1; here it is mentioned as the object of pious preparation by the priests. In *tapata* there is probably a reference to the pious labour or fervour (*tapas*) though only a secondary one.

90

(1) Supply *bhūṣatu* after *upa* from *a*. (2) *putrasya śavaso*: Cf. IV. 24. 1; VIII 92. 14. (3) *an-ati-(a)dbhūtā*: Cf. *na yāsu yakṣam dadīṣe na citram*, VII. 61.5. *yojanā*: "That which joins us with the deity," "a mediator;" cf. *yogyāḥ* VII. 70.4. (4)b: cf. I. 143. 5d. *anānataḥ* i.e., *vṛṣabhaḥ*: cf. VIII. 64.7. (5) Supply *vajreṇa* after *carṣaṇādīḥ* (from *vajrahasta* in v. 4). (6) *bhāgam iva*: Cf. VIII. 96.8; 97.2.

91

Apālā and Indra's favour to her are described in this hymn. The traditional story of Apālā is narrated by Sāyaṇa in the introduction to his Bhāṣya on this hymn. It is also found at Br̥had Devatā, V. 99ff. Also cf. JAOS, 18. p. 26ff. According to this version of the story, Apālā was a married girl, who was abandoned to her fate by her husband owing to some skin disease by which no hair grew on her private parts. She lived with her father who too had no hair on his crown and was possessed of a piece of land which was wholly barren. One day, Apālā found a Soma stalk on her way to the river. She crushed the stalk under her teeth and the sound attracted Indra to the place. She offered Soma juice to Indra, directly from her mouth. Indra drank it and in return for it removed the baldness of her father, barrenness of his lands and her own skin-disease.

This traditional story is however, not wholly borne out by the actual wording of the hymn. Thus Apālā is said to be a *kanyā* (v. 1), a maiden, who is described as *patidvīḥ*, "a hater of a husband" (v. 4) and not *patidviṣṭā*. She is said to have brought

you for Indra ; let me press you for Śakra. (2) (She said to Indra) : Drink this Soma of mine which is pressed by the teeth (i.e., teeth-like implement), which is accompanied by the fried grains, the cake, the gruel and even the Uktha, you who go from house to house (expecting to get Soma), looking lovely in the disguise of a young warrior. (3) We are carefully observing you ; yet we are unable to recognise you (as Indra). (In the meanwhile she addresses Soma) : Flow on for Indra, oh Indu, slowly as it were, gradually as it were. (4) Will he help ? Will he do (as I ask him to do) ? Will he cure us ? Shall I, going about full of a strong dislike for a husband, unite with this Indra ? (5) These are the three regions ; make them vegetate, oh Indra, namely, this his head, and then this (our) barren land and (lastly) this place here right under my belly. (6) Make them all full of hairy growth :—that which is our barren land and then this body of mine, and lastly this which is the head of my father. (7) You made Apālā possessed of a sun-bright skin, oh Śatakratu, by passing her thrice through the hole of a chariot, the hole of a bullock-cart, and then of a yoke.

the Soma stalk to her house (v. 1c) and offered the juice to Indra with its usual accompaniments like the Dhānās, Karambha, Apūpa and Uktha (v. 2). The word *jambhasutam* was very probably early interpreted too literally and that has given rise to the fanciful idea that she crushed the Soma under her teeth and that Indra drank the juice directly from her mouth. This last again must have been responsible for the idea of a love affair between Indra and Apālā, along with the literal interpretation of the word *saṁ gumāmbhai* in v. 4. As a matter of fact, *jambha* may have been only a tooth-like crusher used for pressing, in the absence of the regular press-stones. Besides, vv. 2-3 clearly suggest that Indra had visited Apālā's house in the disguise of a young hero, as was his practice to visit the houses of prospective soma-offerers.

From the wording of the hymn itself the following account may be given. Apālā, a maiden, once found a Soma stalk on her way to the river. She took it home and decided to offer Soma to Indra. She had heard that Indra being fond of Soma, sometimes visited the houses of (irregular) sacrificers, in the disguise of a young warrior. As she was not a regular sacrificer (nor her father was so evidently), she could not offer the Soma to Indra at a sacrifice. Yet in the belief that Indra may visit her house, she crushes the stalk with some Jaws-like instrument and collects other accompaniments of the juice that are usually offered at a sacrifice. Just then a young warrior appears on the scene, while she was mentally addressing Indra in v. 2. This young man claimed the juice, saying that he was Indra. In v. 3, she carefully observes him but is unable to agree that he was Indra. All the while she was still crushing the stalk and pressing out the juice (v. 3cd). The young man persists in his claims and in v. 4 Apālā discusses to herself whether the young man could be Indra and could do her the favours expected by her. She is gradually convinced that it was real Indra who had visited her house and then she offers the juice to him requesting him to grant her three favours, in v. 5 and v. 6. Out of the three, the chief was the removal of her own skin disease and the poet tells us about this alone in v. 7. The operation done by Indra on her is clearly a magical one and it is possible that at one time the hymn may have been used as a spell for the removal of baldness.

(1) *srutā*: loc. of *sruti* "way"; cf. IX. 78.2; X. 88.15. (2) *ab* refers to the popular belief of the times that a deity loved to visit the houses of men in disguise, even when they were not regular sacrificers. In this particular case of Indra, the belief suggests Indra's great fondness for Soma, which he will have whether invited or uninvited, regularly or irregularly. (3) *cana* is positive. (4) She was mainly concerned with her own disease and its cure, and was anxious to know whether by contacting the young warrior before her she would be able to contact the real Indra (v. 4d). (5) *śīras*, *urvaram* and *idaṁ* all stand in apposition to *tāni* which is the object of *vi rohaya*. (6) In correspondence with *a* and *c* and in view of *sarvā tā* in *d*, we expect nominatives in *b*. Yet accusatives are used which are therefore, to be directly construed as object of *kṛdhī*. (7) The hole is intended to be smaller every time; yet the real significance of the magical operation is probably lost to us.

(1) Sing to Indra who drinks the gladdening Soma, who overpowers all, who is possessed of a hundred powers, who is most liberal to men ; (2) who is often invited and praised, who leads the chorus and who is famous from very old days. Say out 'It is Indra'. (3) Active Indra alone is the giver of great gifts to us. The great one has kept us (always) with bent knees. (4) Indra of lovely jaws has indeed drunk the intoxicating Soma mixed with barley flour, offered by the sacrificer Sudakṣa. (5) Do sing aloud to that Indra that he may drink Soma. For, that alone invigorates him. (6) Having drunk the intoxicating juices of this divine (Soma), the god has overpowered all creatures by his might. (7) Do move hereward for protection that ever-victorious god who is associated with all sorts of hymns ; (8) who is a reliable and invincible fighter, a drinker of Soma unmoved (from his position), manly and possessed of resistless powers. (9) Bestow riches on us abundantly, being appreciative (of our praise), oh praiseworthy Indra. Protect us in respect of the prize which must be won. (10) Come to us even from this place, oh Indra, with nourishment consisting of a hundred and a thousand foods. (11) May we attain to the providential cares of the prudent (Indra); may we conquer with our horses in the battles, oh Śakra, lord of the Vajra and giver of the cows ! (12) We make you rejoice in our hymns, oh Śatakratu, as cows rejoice in the pasture-lands. (13) All creatures are running after their respective desired objects, owing to their mortal nature, oh Śatakratu; (so) we too have reached our longed-for destinations (through you). (14) The pleasure-seekers have always rightly relied on you, oh son of strength. Nothing is greater than you, oh Indra. (15) Such as you are, oh mighty god, favour us well with your hastening providential care, which is most liberal (to the worshipper), but formid-

(1) *pāntam* is rather an adjective, than a noun as suggested by Ludwig and Oldenberg (Noten, I, p. 122), in view of the accusative *indram*. The corresponding passages I. 122.1 and 155.1 both show that if a noun had been intended, the dative *indrāya* should have been used. (2) Construe *ab* with v. 1. *gāthānī* is one who leads a chorus ; cf. I. 190.1. c: The poet means: Whenever any distinguished act of bravery or of liberality is mentioned, you may safely say that it is Indra who has done it. It is significant that the line occurs after the mention of about eight of Indra's characteristic epithets. (3): Supply *naḥ* from *a*; *abhiḥṇu* is adverb. It refers to a particular respectful sitting posture of the lower body adopted in the worship of a deity. The line means that Indra has commanded our continued respect by his great deeds. For *naḥ ā yamat* cf. IX. 44.5; X. 14.14. Also see below v. 31. Ludwig's translation "may the great one bring (them) in close proximity (in our lap)" does not seem to be likely. (4) *sudakṣa* may either be a proper name or an adjective of *andhasaḥ*; for the latter, cf. IX. 105.4; 108.10 (Trans. the drink which confers pious strength and is accompanied by an offering — *praḥṣa*). (5) *giṃṣu āyatam*: Locative is peculiar; Instrumental is usual; cf. VIII. 4.2; 31.2. (6) *pārye dhane*: Usually we get *ahani* or *divi* with this adjective. Here it either means "that which must be crossed i.e., won" or "that which is helpful in crossing"; for the latter meaning cf. *pāryam vajram* I. 121.12; *pāryāya avase* IV. 25.1; and *pāryāḥ dhiyaḥ* VII. 27.1. (7) I construe *a* and *be* as two corresponding sentences. *dhīvan* is Indra and his *dhiyaḥ* are his providential cares. Cf. v. 13 and 15 below. *arvadbhīḥ jayema*: Cf. I. 27.9 ; 64.13; VI. 45.12; VII. 90.6; VIII. 2.36; 19.10. *godari*: from *go* and *dar* to break open, to give. (8) *gāvo na*: Cf. I. 91.13; V. 53.16; X. 25.1. In view of *tvā raṇayāmāsi*, we should have the accusative *gāḥ na*; but under the influence of the prominent word *vayam* and the metre, we get the nominative; on the other hand we get *gāḥ* the accu. in place of *gāvaḥ* at IX. 112.3. (9) Supply *jātā* in *ab*; *marīyatvanā* is instrumental in *ā. anukāmā* is an adjective of *viśvā* "running, hankering after desired objects". Cf. *kāma-kātayaḥ* in v. 14 below and *pulukāmo hi marīyaḥ* I. 179.5. *āsasaḥ* is the object of *aganma*; cf. v. 11a above. (10) *kāmakātayaḥ*: *kāti* from *kan-kā*; cf. *ṛnakāti* at VIII. 61.12. *tvē avītran*: cf. *tvē abhūma* II. 11. 12a. *c* is identical with v. 22c. (11) *purandhyā dhiyā*: Indra's providential care is meant; cf. VIII. 69.1. *dravītnu* "hastening for helping men". Agni

able (to the enemy). (16) Now you may rejoice in our intoxicant drink by (enjoying) your wild delight which is the most glorious one, and which even now belongs to you, on Śatakratu ; (17) which enjoys best fame, which is the best killer of the Vṛtras, and the best giver of vigour (to you). (18) For, we know (that Mada of yours), which being granted to them by you, exists among all men, oh wonder-worker, oh unfailing drinker of Soma and lord of the Adri. (19) Let our hymns give additional strength to our pressed juice, for the sake of the spirited Indra. Let our bards sing a song to him. (20) We invite to the juice that Indra in whom all glories and the seven assemblages find their restful joy. (21) The gods performed a sacrifice which took note (of Indra) at the Trikadrūkas. Let our hymns glorify him alone. (22) May these juices enter you as rivers enter the ocean. None is greater than you. (23) By your greatness, oh mighty god, you have made sufficient room for the potion of Soma which has entered your belly, oh watchful god. (24) May this Soma be agreeable to your side, oh killer of Vṛtra; may the juices be helpful to your powers. (25) Śrutakakṣa sings pleasantly for the sake of horse, for the sake of cow and for (winning) Indra's power. (26) You surely feel happy at our pressed juices, oh Indra; they are highly pleasing to you (when you are inclined) for a gift. (27) Even from afar, our hymns have clung on to you, oh lord of the Adri; may we happily go to you. (28) Thus indeed do you long for brave warriors; thus are you brave and firm. Thus is your mind inclined for a gift. (29) Thus was a sacrificial gift offered to you by all sacrificers, oh Indra of ample gifts; and surely mine also by their side, oh Indra. (30) Do not be negligent like the Brahman priest, oh lord of treasures. Rejoice in the pressed juice mixed with milk. (31) May not the revilers overpower us during the dark rays of the sun. May we obtain that with you as our companion. (32) With you alone as our friend, may we oppose our rivals. You are ours and we yours. (33) May the bards who are your loyal friends, serve you alone, praising you continuously, oh Indra.

93

(1) Surely you rise up to greet that Bull, that archer of well-known bounty whose acts are helpful to man, oh Sun; (2) that killer of Vṛtra, who battered down the nine and ninety forts (of Śambhara) by his Vajra

is requested to yoke his "hastening chariot" at X. 11.9. (17) Cf. VIII. 46.8. (18) Śāyana supplies *rayiḥ* after *trāḍattah*; but perhaps *madaḥ* was meant by the poet. Indra's *mada* is brought to men at their request at VI. 19.7. (20) *a*; cf. I. 85.2; 139.3; 166.10; VIII. 20.12. (21) *cetanam yajñam*: See note on VIII. 13.8; *taṁ* is surely Indra and not Yajña. (22) *vijyaktha*: from *vyac* to "contain with ease"; cf. III. 36. *Sub. jāgyre*: This epithet is commonly used of Soma; here it is transferred to Indra from the Soma who is within him. (26)c: Supply *somah sūch* from *ab*. (28) *śreyah*: Vias are the brave patrons of the poets. (29) Supply in *c rātiḥ dhāvi*. (30) *brhmad tandrayah*: The priest called Brahman whose duty is general supervision, is very likely meant here. Having no duties in particular to perform, he is likely to doze a little and be negligent. (31) *sirah akṣay*: The nightly rays of the sun are meant; cf. I. 115.5; so "during the nights". *tat* refers to what is said in *ab*. *ādiś* is "one who calls names or censures others".

93

The sun, while rising, is addressed in vv. 1 and 4. In the former, it is said that the sun rises up to greet and honour the great warrior Indra. In the latter, both the sun and Indra are addressed. The meaning of the stanzas is however generally clear. Indra is the sovereign ruler of all things over which the sun rises. The composition of the hymn presupposes a situation in which the rising sun is before the poet's mind. (1) *astāram*: The poet has in his mind the event of Indra's shooting the Varāha at the time of his meal before the Vṛtrahanana. Cf. on 77.6 above. (2) *bahujasā* is a Bahu-

which has its strength derived from his arms, and who slew Ahi. (3) That our kind-hearted friend Indra yields to us (a gift) consisting of horses, cows and corn, like a cow giving milk in broad streams. (4) All that is under your control, oh Indra, killer of Vṛtra, over which you have risen today, oh Sun; (5) And when you think that you will never die, oh mighty good leader, it is absolutely true in your case. (6) You claim all those Somas, oh Indra, which are pressed either far or near. (7) We strengthen that Indra for killing the great Vṛtra. May that Bull be mighty. (8) That Indra was created for (giving) gifts; the mightiest one was destined for the wild joy (of Soma). He the glorious and praise-worthy god, deserves Soma. (9) Like his well-developed Vajra, the invincible Indra grew powerful, unmoved and mighty, by means of our hymn. (10) Being praised by us, make our progress easy even in a difficult place, oh Indra lover of hymns; and you yourself must will it. (11)—you, whose command and self-rule no god nor undaunted mortal can violate. (12) Both the divine worlds honour your absolutely unopposed strength, oh Indra of lovely jaws. (13) You have put this bright milk in the cows which are dark, or red or dappled. (14) When all gods ran helter-skelter before the wrath of Ahi, the might of that beast (Ahi) nevertheless did attack them. (15) But immediately then my protector presented himself there; the killer of Vṛtra who is invincible and for whom no slayer was born, directed his manly strength against (Ahi). (16) I praise for a great bounty that your well-known and mightiest Vṛtra-killer, who is the source of power to men. (17) And (I praise you) with this loot-seeking hymn, since you present yourself at every Soma sacrifice, oh god praised by many under many names. (18) May the killer of Vṛtra who enjoys many libations, have his mind observing us. May that Śakra listen to our prayer. (19) With which favour would you delight us, oh mighty god, and with which (favour)?—just by that favour bring wealth to the singers. (20) In whose juice did the mighty Indra possessed of the Niyuts, the killer of the Vṛtras, rejoice for drinking Soma? (21) Being filled with wild delight, be the giver of thousand-fold wealth to the worshipper. (22) The pressed juices accompanied by their wives (i.e., the waters), go forth for his feast, longing for

vrihi compound and hence supply *vajrena*. (3) *urudhārā* i.e., *dhenuh*; cf. VIII. 1.10 and IX. 69.1. (5) *c*: Cf. I. 1.6; 98.3; III. 32.9. (6) Cf. VIII. 13.15; 53.33; IX. 65.22. (8) *hitah* from *dhā*, corresponding to *kṛtah*; *made* (loc.) is used in place of *madīya* owing to the resemblance of its concluding sound with that of the dative *dāmane* (both ending in *e*). (9) *sambhṛtaḥ vajrah* like *sambhṛtā hari* at VI. 57.3; cf. also VIII. 34.12. (10)*c*: The meaning is: Do not leave this work to any deputy; do it yourself. (13) For the miracle, cf. on VI. 17.6. (14-15) Vv.14 and 45 should be construed together as referring to the killing of Vṛtra. *trīṣaḥ*: Elsewhere we get *śvasatha* as at 96.7 below. *me* in v. 15 is merely ornamental like *vaḥ* in v. 16. (16) *ā śuṣe*: from *ā śvas* “to pant heavily, to exert sincerely, praise earnestly”. Cf. *ṛtam āśuṣānāḥ* IV. 1.13; 2.14; 16. *śardham carṣaṇām*: Cf. II. 1.5d. (17) I supply *tvām ā śuṣe* from v. 16 or *tvām gṛhe* (cf. I. 143.6) in *a. ca* shows that v. 17 is to be connected with v. 16 though there is a change from the 3rd to the 2nd person. (18) *bodhin-maṇaḥ*: Cf. *cikidvin-manasam dhiyam* VIII. 95.5. (19) *abhi pra mandase*: cf. VII. 33.1. In *c*, the construction seems to be anakoluthic: The poet possibly intended to use *ā bharaḥ* (cf. VI. 26.4; X. 171.2); but suddenly he changed his mind and used the imperative as soon as he came to the word *stotrbhyaḥ* owing to the association of the two words (cf. *stotrbhya ā bhara* V. 6.1; VIII. 77.8; IX. 20.4 etc.). He first wanted to know Indra’s practice in relation to the older bards; but then suddenly he requests Indra to do that same favour to the present singers. (20) *niyutvān*: The pun on the word *niyut* is surely meant; cf. on III. 31.14. (21) *abhi* goes with *naḥ* “with reference to us” as at IV. 31.3; *rayim* is the object of *prayantā* (cf. VII. 19.1; IV. 21.9). So, no need to supply *ā bhara* with *Sāyaṇa*. (22) *patniḥ* are the waters with which the juice is mixed; cf. VIII. 69.2. *apām* goes both with *jagmiḥ* and *nicumpuṇaḥ* (from *cump=cumb*?) “visitor

him. He the lover of waters, is their habitual visitor. (23) The offered oblations have mightily flown forward, glorifying Indra at the sacrifice, towards the Avabhṛtha. (24) May these golden-haired horses, who are your feast companions, carry you towards the offering which is laid down. (25) These Somas are pressed for you (oh Indra); the grass-seat is spread out, oh Vibhāvasu. Bring Indra to the singers. (26) I (bestow on you) your spirit. Indra has bestowed bright regions (of the heaven) and rich treasures on his worshipper. Do, sing to Indra for the sake of his bards. (27) I bestow on you physical strength which is peculiar to Indra and also all sorts of hymns, oh Śatakratu. Show mercy to the singers, oh Indra. (28) Bring us every kind of bliss, food and nourishment, oh Śatakratu, if you take pity on us, oh Indra. (29) Such as you are, bring us all kinds of happiness, oh Śatakratu, if you take pity on us, oh Indra. (30) Bringing our pressed juices to you, we call upon you alone, oh best killer of Vṛtras, if you take pity on us, oh Indra. (31) Do come to our pressed juices with your horses, oh lord of the intoxicating juices; do come to our pressed juices; (32) You who are Indra of a hundred powers and who surely are well-known as the greatest killer of the Vṛtras. Do come to our pressed juices with your horses. (33) For, oh killer of the Vṛtras, you are the drinker of these Soma juices. Do come to our pressed juices with your horses. (34) May Indra hand us over to Food; may the powerful one give us vast, pleasing and abundant riches.

95

(1) My hymns have mounted upon you as a charioteer (mounts upon his chariot), when the juices are pressed, oh lover of the hymns. They have greeted you as the mother-cows greet their calf, oh Indra. (2) The bright juices have moved you towards us, oh Indra, lover of the hymns. Do drink of this gladdening juice; it is laid down for you among all people, oh Indra. (3) For the sake of wild joy drink surely this Soma which was brought by the hawk and which is now pressed by us, oh Indra. For, you are the imperial lord of many people. (4) Hear the call of this Tiraścī, who worships you, oh Indra. Give us wealth accompanied

and lover of the waters". *c* records the usual habit of Soma, who is now mentioned in the singular number, being half conceived as a divine being. (23) *avabhṛtha* is the final bath. This technical meaning of the word may have been meant here in this passage which mentions also the Hotrās. (25) In *a* Indra is addressed; in *bc* which belong together, Agni is requested to bring Indra to the spread out grass for the sake of the singers; cf. VIII. 17.15 and note. (26) Supply *dadhāmi* in *a* (from *dadhat* in *b*); see also v. 27*a* below. *vi rocanā* belongs to the next sentence in *b*; note the repetition of *vi*. To bestow *rocanā* on a worshipper is to lead him to the heaven. *c* is addressed to the followers by the poet. Vv. 25-27 form a *tīca* characterized by a slightly varying refrain. Similarly vv. 28-30 and 31-33 form *tīcas*. In the latter, the refrain is put also at the commencement. For a similar decoration, cf. VIII. 97. 7-9 and IX. 58. 1-3. (34) Evidently the poet intended to employ a pun on the words *ṛbhu* and *ṛājan* making them applicable both to Indra and the *rayi*. Undoubtedly here he was under the influence of the line *ṛbhum ṛbhukṣaṇo rayim* IV. 37.5; so that the adj. *ṛbhum* was already fixed; the question was about the second word: *ṛbhukṣaṇo* either as nom. or as voc. was out of the question owing to the context. *ṛbhukṣā no* which is the next possible imitation of the word, could not be used after *ṛbhum* in the line owing to metre; it was therefore placed before *ṛbhum* and then the line would read *ṛbhukṣā no ṛbhum rayim*. But then *naḥ* becomes repeated too soon after the *naḥ* in the first line; so that ultimately the poet is compelled to use *ṛbhukṣaṇam*, the accusative, as an adjective of the *rayi*, which, by the bye, occurs only here.

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(1) To complete the simile in *ab* supply *ratham* which is usually associated with the root *āsthā*. (2) Supply *vikṣu* in *d*; cf. v. 3*d*. (4) Tiraścī is the name of the poet. *mahān*

by good physical strength and cows ; you are great. (5)—That Tiraści, oh Indra, who has composed for you a newer delightful hymn, an ancient prayer which augments the Rta and possesses a critical mind. (6) Let us praise that Indra alone whom hymns and prayers have glorified. Seeking loot, we love (to praise) his many manly deeds. (7) Come, let us praise pure Indra by means of a pure Sāman. May the pure Soma mixed with its ingredients gladden Indra who grows powerful by means of pure hymns. (8) Come to us being purified, oh Indra, pure, with pure favours. Being pure, bestow wealth on us ; being pure and fond of Soma, enjoy yourself. (9) Being pure you gave us riches ; being pure, you (give) treasures to your worshipper, oh Indra. Being pure you kill the enemies ; being pure you seek to win loot.

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(1) In obedience to Indra, the sweet-voiced Dawns finish their journey (and) the all-covering nights pass on through the nightly darkness. For fear of him the motherly waters, the seven rivers, stand ready for men to cross, offering them an easy ford. (2) Thrice seven peaks of the mountains lying close to each other, were completely pierced by the archer though he was not very firmly poised. Neither a god nor a mortal can destroy that which the mighty Bull has performed. (3) The metallic Vajra is fond of Indra ; in Indra's arms there is abundant vigour. Great mental powers are in the head of Indra in exuberance ; they run right into his mouth, in order that he may be heard all around us. (4) I regard you as the holy one among the holy gods and as the mover of the unmoved (enemies). I regard you as the banner of the victorious warriors and as the mighty lord of the people. (5) When you place the Vajra which is restless through wild joy, in your arms for killing the Ahi, oh Indra, the mountains, the cows and the priests greet you loudly,

asi : This is an oft recurring expression ; cf. I. 36.9; 94.5; III. 46.2; IV. 9.1; 30.2; VII. 11.1; 31.7; VIII. 60.6; 19; 64.2; 98.2; 101.11; 12; IX. 66.16; X. 152.1. (5) *navīyasim-prathnām* : Newer from the point of decoration, appeal, sense etc. ; but old from the point of the main principals of praise laid down by the ancient bards, hence also *rtasya pīṇsim*. (7-9) The *hīa* characterized by the word *buddha* seems to have been composed for some sacrificial purpose. In v. 9ab, supply *dadāsi*.

96

(1) The two sisters, Night and Dawn go on their respective journeys in obedience to Indra. Mark the sense of the dative. *ā tir* "to cover up, finish etc.". *suācāh* is appropriate for Uṣas only; cf. III. 7.10; yet it is applied to both by stylistic transference. *urnyā* is conceived as a Devi as at V. 61.17 and X. 127.6. *nakṭam* means "nightly darkness", since *nakṭam* stands parallel to *yānam*. The reference in *cd* is to the general facilities of intercommunication and water-ways afforded by the rivers to men, and not to particular incidents when certain men were allowed to cross the deep rivers. (2) *āthruṇa* : From *tyath*. An archer must be firmly poised before he takes his aim; Indra was not even so poised and yet he pierced the crowd of peaks in front of him and hit the boar beyond them. Though the Vajra is mentioned in v. 3 the reference in this stanza is to the shooting of an arrow as at VIII. 77.6; 11. It would seem that Indra shot down the boar from a mountain, whose peaks must have stood between him and the boar. See on 77.6 above and I. 61.7. The stanza has evidently no connection with the legend of the flying mountains. (3) cf. II. 16. 2cd. The subject of *ā iṣanta* is either *sonāh* (in view of II. 16.2c), or even *kratavaḥ*, *śrutyai* being the purpose. The idea is: Indra's Kratus go down to the mouth (of Indra? of the singers? Perhaps of both,) assuming the form of hymns of praise in order that he may be known far and wide: *āsan ā*: Cf. *mīmīhi ślokaṃ āsye* I.38.14. *śrutyai*: Cf. II. 2. 7b; X. 111.3. (5) *madacyutam* : Indra's horses too are called *madacyut* "moved by the wild joy of Soma", at I. 81.3; 126.4; VIII. 33.18; 34.9. *mada* in Rv. does not mean "pride"; so *śatrūṇām madasya cyāvayitām* (Sāyana) is not correct. In *cd* we have a reference either to the preparation of Soma (cf. VI. 40.2cd; VII.42.1), or to Vala's cave, the imprisoned cows and the Aṅgirases (cf. V. 30.10; 45. 8ab). The mixing up of the Vṛtra and the Vala legends is not unusual in

clinging fast to you. (6) Let us praise him alone who has created all these creatures which are younger than him. Let us seek to make friendship with Indra by our hymns; let us enter into the presence of the mighty god by means of our prayers. (7) All gods, your friends, left you, oh Indra, running away from the breathing sound of Vṛtra: (but) let your friendship be with the Maruts. May you then conquer all these armies. (8) Thrice sixty Maruts (stand) glorifying you, the holy ones, like herds of cows. We approach you; give us our share. Let us honour your strength with this offering. (9) Who has dared to oppose the sharp weapon, the onslaught of the Maruts and your Vajra? The demons who defy the gods are without an effective weapon (against you); strike them down with your (chariot's) wheel, oh mighty god. (10) Send your well-trimmed hymn as the animals (to draw his chariot), to the great, fierce, powerful but kindest Indra. Offer many hymns to Indra who is drawn by the hymns, for his own person. Will he please take note of this? (11) Send your hymn to the mighty god whose vehicle is a hymn, as the boatman sends a person to the yonder bank of the rivers in his boat. Cling closely to the body of the famous and dearest Indra with your hymn; will he appreciate this? (12) Perform that which Indra may like of you; sing a good hymn of praise. Serve him with a prayer. Wait upon him oh bard, do not cry; make him hear your speech. Will he appreciate this? (13) The dark coloured drop took his bold stand on the stream of the Amśumatī, when he was attacked by ten thousand (foes). Indra helped him while he stood blowing them away vigorously. The bold-spirited Indra wiped out the destructive spirits. (14) (Indra speaks to Maruts):— I saw the Drop moving about like a cloud in the dangerous valley of the Amśumatī river, taking his determined stand on it. I urge you on (to his help), oh mighty ones; do fight in the battle. (15) Surely, the Drop being in high spirits, firmly planted his body on the bosom of the Amśumatī; (and) Indra with Bṛhaspati as his companion overpowered the demonical warriors

R̥gveda. (6) *mītram dhā*: cf. X. 34.14; 108.3 (7) Cf. IV. 18.11 and 93.14 above. It is possible to construe vv. 7-8 as the speech of the Maruts addressed to Indra before killing Vṛtra. This construction gives a better meaning to the verses. (8) *usrāh rāsayaḥ*: The case termination of *usrā* is dropped. (9) *tigraḥ śāntam* stands either in apposition to *anikam*, or is a reference to *cakram* in *d. marutām śāntam*. 'Face, front, onslaught of the Maruts'; cf. I. 168.9; VI. 47. 28. *cakra* is of course the chariot-wheel. (10) *at*: First sentence ends with *peraya*; *paśāḥ* and *giraḥ* (with the particle of comparison supplied) are to be construed as the objects of *dhūhi* (cf. VII. 24.5ab). *tante dhūhi*: cf. *tanvi nī sṛṣā* in v. 11. *kuvīdanga vedat* is the refrain of the Tṛca. (11) The simile is not clearly expressed. As it is, *manīṣā* seems to be compared with a traveller (supplied), Indra with *nadinām*, the deep bottom of his heart with the other bank (*pāram*) of the rivers, *drupā na* being merely descriptive, showing the ease of the act: "Send the hymn down to (the deep recesses of the heart) in Indra's body, as a boatman sends a traveller to the yonder bank of rivers in his boat". But we rather expect Indra to be the object of *iraya* in view of the epithet *ukthavāḥase* and also of the comparison of a hymn with a boat at I. 46.7 and X. 116.9. In this case *ab* would mean "Send a hymn to Indra; send him to us in it, as they send a traveller in a boat to the other end of the rivers". In the last stanza, a hymn is conceived as a horse; here as a boat. In *c* construe *tanvi nī sṛṣā* and cf. VI. 49.12. (13) *drapsa* is the Soma (cf. X. 17.11-13), *kṛṣṇaḥ* is its adjective and *ityāḥ* is passive. *ava atīṣṭhat* "took a firm last stand"; cf. *kṛṣṇam avatasthivāmsam* in v. 14 and *tanvām adhārāya* in v. 15. *tam* in v. 13 is of course the Drapsa. *snēhīti* (from *snih* "to be inimical"; cf. IX. 97.54) is the same as *snīhīti* (I. 74. 2) and an adjective of *tīṣaḥ* supplied (cf. v. 15c). (14) This is addressed by Indra to the Maruts. *avatasthivāmsam* i.e., *amśumatīm avatasthivāmsam*. But the real difficulty is the epithet *kṛṣṇa* of Soma; this epithet is invariably used of the dark-coloured demons in the R̥gveda, while Soma is either *hari* or *babhrū*. Perhaps the original legend was something like this: Soma was moving about unguardedly in the valley of the Amśumatī (Is this a significant name? "abounding in the Amśus"?); he was noticed by the Asuras and immediately surrounded by them. Seeing no other

who were attacking him. (16) It was indeed you who soon after you were born, became the killer of those seven who (thought they) were without a slayer. You discovered the heaven and the earth which were hidden (in darkness). You gave delight to all creatures which are spread far and wide. (17) It was indeed you, who, being bold, killed with your Vajra the matchless might (i.e., Vṛtra). You overpowered (the might) of Śuśna by your weapons; you won back the cows by your power alone, oh Indra. (18) It was indeed you who the mighty one became the slayer of the enemies, oh lord of the people. You set free the rivers which were blocked up (by Vṛtra). You conquered the waters which were mastered by the Dāsa. (19) He is wise, who takes delight in the pressed juices, whose wrath is unopposed, who is glorious like the days, who alone is the performer of manly deeds. He is the killer of the Vṛtras; they (i.e., the Vṛtras) surely oppose another one (but him). (20) That Indra is the killer of Vṛtra and the supporter of men; him who is fit to be called we invite with our good praise. He is Maghavan, our great defender and advocate; he is the giver of food which is associated with fame. (21) He, the mighty Indra, is the Vṛtra-killer; he became fit to be called upon as soon as he was born. Performing many manly deeds, he is fit to be invoked for his friends like the Soma that is drunk.

97

(1) Bestow on your singer all that namely, whatever enjoyments you, the glorious one bring from the demons, oh Indra; (bestow them) on those who offer you a sacrifice. (2) Bestow on that sacrificer who presses the Soma and brings you Dakṣiṇā, your exhaustless share, namely a horse, a cow, which you hold. Do not give it to the Paṇi. (3) Let that person who sleeps without obeying the holy laws and who is godless even in his sleep, destroy his nourishing wealth by his own deeds; put him away from it in some unknown place. (4) Whether you are far away or near, oh Śakra, Vṛtra-killer, from that place does this sacrificer seek to win you with his hymns serving as the horses moving in the air. (5) Whether you

way of escape, Soma assumed the form of an Asura and was about to escape; but unfortunately, he was found out and then attacked by a large force of the demons. But Soma took a bold stand and was trying to disperse the army of the demons. Just then Indra observed him and saved him with the help of the Maruts and Brhaspati. The *trcas* 13-15 (*drapsa*), 16-18 (*tvam ha tyat*) and 18-21 (*sa vṛtrahā*) are distinct units. (17) *apratimānam ojaḥ* is Vṛtra; supply *ojaḥ* in *e* from *a* and cf. I. 121. 10cd. (18)b; cf. I. 4.8b. (19) *ahā iva revān*: cf. *vibhrājamānān ahā iva* IV. 33.6. *naryā apānisi* "acts which are found in a hero," or "deeds which are favourable to man". In effect the same as *naryā apānisi* in v. 21 below and at IV. 19.10. At VIII. 93.1 Indra is called *naryāpas*. d: I take *vṛtrāṇi* supplied as the subject of *prati āluh* which means "oppose, stand against" (cf. *prati brū* at VIII. 21.11; 92.32). *anyam* is surely with reference to *vṛtrahā* which is the important word of the *Trca*, and not with reference to *vṛtra* as assumed by Śāyana and Geldner ("They say he is also a match for every one else"). Ludwig and Oldenberg take it still differently: "They contest the claim of anyone else to this title" (i.e., Vṛtrahā). But the meaning of *prati āluh* is not very favourable to such a construction. (21) *soma na pītaḥ*: Cf. I. 179.5; VIII. 48.4. The whole of the latter hymn is a clear evidence to show that Soma was drunk as a part of the ritual and then appealed to for help.

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(1) *asya* in spite of different number and gender, refers to *bhujh*, in *a*. It is also the means of *vardhanya*; thus *gene*. in place of *instru.* as at II. 11.20; V. 20.2. Or as Ludwig construes, *asya* refers to the act of Indra described in *ab* and goes with *stotāram*: "Lead to prosperity that person who praises this act of Indra namely that he brought etc.". (3) *svaīh evaiḥ*: cf. VIII. 18.13; also see II. 23.6. *tataḥ* i.e., away from that *rayi*. (4) *gīrbhīh* in apposition to *keśibhīh*; *dyugāt* is adverb. Or, *gīrbhīh* is Karaṇārthe and *keśibhīh* is Sahārthe Trtiya: "Seeks to bring you with his hymns along with your horses". (5) *samudrasya viṣṭāpi*: cf. IX. 12.6; 107.14. *Samudra* is the aerial lake of

are in the bright regions of the heaven or in the world of the Soma-ocean, whether in some earthly house or in the mid-air, oh best killer of the Vṛtras, do come. (6) Such as you are, oh drinker of Soma, oh lord of strength, be delighted with our pressed juices, (coming) with a kindly gift and abundant riches, oh Indra. (7) Do not avoid us, Indra; be our feast-companion. You are ours with your protection; you alone are our relative. Do not avoid us, oh Indra. (8) Seat yourself down with us at our pressed juices, for drinking the sweet drink, oh Indra. Grant your great protection to your singer, oh Maghavan, (being) here with us at our pressed juice. (9) The gods do not reach you (in point of greatness), nor do the mortals do so, oh lord of the Adri. You are the over-powrer of all creatures by your might. The gods do not reach you (in greatness). (10) They have fashioned Indra as a warrior who more easily overpowers all inimical armies—they also created him for rulership—who is the best by his wisdom, who is a ruthless killer when opposed, and who is fierce, most mighty, strong and active. (11) The bards have together sung him a call for the draught of Soma, since they (call) this lord of the heaven for advancement. For, he is the upholder of the law by means of his favours and powers. (12) The priests bend the tyre by their eye, (and) the ram by their sweet song. The bright ones as well as the eloquent ones are close to the ear of the unharmed and active Indra. (13) I invite that liberal fierce Indra, who suddenly assumes great powers in a resistless manner. May the most liberal and holy god turn towards us by our hymns. May the wielder of the Vajra make all paths easy for us that we may win riches. (14) You are wise enough to destroy these forts by your power, oh most mighty Śakra. All created things, heaven and earth, tremble through fear from you, oh Vajrin. (15) May that sacrifice of mine protect me, oh wonderful and brave Indra. Carry us safely across many dangers like rivers. When will you send us all-round enviable riches, Oh royal Indra?

98

(1) Sing a mighty Sāman to Indra, the great priest, who is the maker of Law, who is wise and who longs for praise. (2) You are an overpowerer, oh Indra; you brightened up the sun. You are the doer of all the deeds and lord of all the gods; you are great. (3) Brightening up the sun, you went to the bright firmament of the heaven. The gods yielded them-

Soma; see VIII. 6.29. (6) *rāvā pariṇasā*: See on IV. 31.12. (10) *riṣṭāḥ pṛtanāḥ* goes with *abhihūtarām*; the subject of *tataksuh* and *jayanuh* is *devāḥ* from v. 9. *vare āmurim*: *vare* is the loc. of *vara* 'opposition'; cf. *na yo varāya* I. 143.5. Usually *āmuraḥ* are said to be unable to oppose Indra; cf. (*na varantā*) IV. 31.9; VIII. 24.5; here the poet tells us that if they choose to do so Indra himself becomes their *āmuri* (i.e., *āmuri* of the *āmuraḥ*). (11) I take *c* as a relative clause (with *scaranti* supplied) as is suggested by *yat. sam* in *d* is merely decorative as in v. 12*d*. Both vv. 11 and 12 are Anustubhs with an appendage of 4 letters at the end. *viprah sūditayāḥ* in v. 12 are the same as the *rekhāsāḥ* in v. 11 (Udgātrs? or Adhvaryus?), the Rkṣans being the Hotṛs. (12) Meṣa is Indra himself; cf. I. 51.1; 52.1; VIII. 2.40. He is compared with the tyre of a wheel, but the particle of comparison is dropped. For the simile, cf. VII. 32.20; VIII. 75.5. *adruhaḥ* and *tarasvināḥ* are both adjectives of *indrasya* supplied. The presence of *vaḥ* before *adruhaḥ* is favourable to this construction. (13) *apratīṣṭakutām* is either an adverb or an adjective of *indram* awkwardly shoved in between *dadhānam* and *śavāṃsi*, owing to metre. (14) *cikit* goes with *nāśayadhyai*; or supply *jātaḥ*. (15) *aṭo na duritā*: For the simile, cf. on V. 4.9 at JBBRAS., 1940, p. 8. The metre in v. 10 and 13-15 is irregular; in v. 10 it is Jagati with a word shoved in here or there, while in vv. 13-15 it is Triṣṭubh similarly inflated.

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(2) *viśvakarman*: Everywhere else, he is a separate deity comparable with the Upaniṣadic Brahman. (3) *svaḥ* is the sun; *ab* is intended to show how Indra is brighter

selves to you for your friendship. (4) Come to us oh Indra, being dear—you, who are a sure conqueror, undeniable, vast in every way like a mountain, and the lord of the heaven. (5) For, oh you unfailing drinker of Soma, you have outgrown both the worlds. You are the furtherer of a sacrificer who presses the Soma ; you are the lord of the heaven. (6) For, you are the breaker of many forts, oh Indra. You are the killer of the Dasyu, furtherer of man, and the lord of the heaven. (7) We send out our great desires to you, oh Indra lover of our hymns, as those who move about with waters send their waters. (8) Our hymns glorify you with our Yavyās (i.e., friendships), oh brave lord of the Adri, who grow powerful day by day, like rain-water. (9) They yoke the horses which are yoked by hymns and which carry Indra, to the chariot of the impetuous one, which is great and has a great yoke, by means of their hymn. (10) Bring us oh Indra, vigour and manly strength as also a brave warrior who defeats the armies (of foes), oh wise god of hundred powers. (11) For, oh god, you are our father and mother, oh Śatakratu. Indeed, we ask for your favour. (12) I speak to you who seek loot, oh Śatakratu, oh mighty oft-invited god. Such as you are, grant us good physical strength.

99

(1) Energetic men have filled you alone full, today and in the past, oh Vajrin. Such as you are, listen to (the call) of your bards ; do come to your own resort. (2) Rejoice, oh lord of the bays and possessed of a lovely chin ; that we ask of you. The priests wait on you ; your famous deeds are best and deserve a hymn at the pressed juices, oh Indra lover of the hymns. (3) Enjoy all treasures of Indra, cooking the sun as it were. We have regarded all the treasures as our own share, since he was born with might, or since he is showing himself so even now. (4) Praise this giver of wealth whose bounty is not meagre. Blessed are Indra's gifts. He does not offend the desire of this his worshipper, when he directs his mind towards a gift. (5) In battles, you overpower all the rival foes, oh Indra. You are the destroyer of curses and an all-conquering disposer. Do you conquer the enemies who seek to win. (6) Heaven and Earth have lovingly followed your overpowering might as the mother follows a child. All the rivals perish before your fury, when you overthrow Vṛtra. (7-8) We call your Indra for a favour, with his protection hereafter,—Indra, who is ageless, who scares away (the foes), but is himself unscared, who quickly conquers and encourages (the worshippers), who

than even the sun; cf. IV. 16.14. (7) The simile is obscure. Does it refer to the water-carriers? *udabliḥ yan* is like the *nāvā yan* at III. 32.14. *udā* is accusative plural. Or, are the clouds meant? "We send you our desires as profusely as clouds send their waters". (8) Even here the simile is not very clear. Is *vā* an Upamāna for *trā* (accu.) or for *brahmāṇi* (nom.)? In the former case *vā* is the ocean; in the latter, it is rain water, flooding the streets (cf. II. 4.9; X. 145.6). *yavyā* is another difficulty. It belongs only to the Upameya and not to the Upamāna. (9) The subject of *yunjanti* is *viṣṇūḥ* supplied.

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(1) *bhūrṇayo narah* : priests are meant; cf. IX. 15.3. (3) "Cooking up the sun" is an unusual idea, connected with *bhākṣata*, either as its cause or its effect. Does it suggest the power, the claim to do anything under the sun under the patronage of Indra? Or, does it mean "brightening up the sun, ensuring his heat and brilliance as it were"? But how would this latter be either the cause or the effect of the "enjoyment of Indra's treasures"? (4) *b* : Cf. VIII. 62.1-12 (refrain). *d* : Cf. I. 48.4ab. (5) *janitā* i.e., *kāmanām* supplied from *kānam* in v. 4; cf. VIII. 36.5. *tūrya* is a verbal form. (6) *śnathayanta* : Śāyana reads *śrathayanta* and this is correct; cf. V. 85.4. (7) *prchetārcm-cṛchitām* : see note on VI. 18.1. (8) *aniṣkṛtam* : *enih kṛtom* (Padapatha). Perhaps it is *an+iṣkṛtam* in view of the note on v. 7. *samānam* : Cf. I. 131.2; VIII. 45.28.

is the best chariot-fighter, who is unconquered, who supports the Tugryas, who polishes what is unpolished, who performs daring acts, who has a hundred powers and a hundred favours, who is common to all, who is rich and impels riches (to men).

100

(1) Viṣṇu speaks :—Here I personally go ahead of you ; all gods are following me from behind. When you assign a share to me, oh Indra, immediately then you may perform deeds of valour together with me. (2) Indra speaks :—I immediately assign a draught of the sweet drink to you ; let the pressed Soma be set aside as your share. May you be a friend of mine standing to my right side, and then let us kill many Vṛtras together. (3) The poet speaks :—Bring forth your unfailing hymn to Indra, thereby strengthening him, if Indra were really existing. For, some maintain that Indra does not exist ; (they say) who indeed has seen him, whom shall we praise ? (4) Indra speaks :—Here am I oh

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The hymn is variously tackled. The Vedic tradition preserved in the Bṛhad Devatā 6. 117 ff., is the basis of Sāyaṇa's explanation which even Geldner adopts in his *Kommentar*. According to this explanation, vv. 1-2 are said by the poet; they contain, in the form of a dialogue, a pact of friendship between Indra and the poet. In v. 3 the poet asks his followers to begin their song to Indra, in spite of the doubt about his very existence expressed by some. Vv. 4 and 5 are spoken by Indra who appears in person before the poet to convince him. Vv. 6-9 contain the praiseful hymn of the poet. This leads the poet to the divine Vāk who manifests herself in the thunder; in vv. 10-11 therefore, this Vāk is praised. V. 11 appears to be the proper conclusion of the hymn. V. 12 stands isolated and belongs to the Vṛtra episode. Ludwig thought that it was Agni who spoke vv. 1-2. According to Oldenberg, *ZDMG.*, 39, p. 54 ff, it is Vāyu. In any of these explanations the unity of the hymn does not seem natural. I therefore venture to propose a new explanation without claiming any finality about it. The last stanza of the hymn seems to me to be the key to the whole hymn. It refers to the slaughter of Vṛtra and this same is the main theme of the entire hymn. Indra required the assistance of Viṣṇu at that time and this is often mentioned throughout the *Ṛgveda*. Cf. in particular IV. 18. Our hymn is similar to this hymn in point of conception and lay-out. Like it, ours too is a Samvāda between Indra, Viṣṇu and the poet who imagines himself to have been present at the time when the event took place. So v. 12 is the basis of the fanciful composition of the poet namely, vv. 1-11. I shall now proceed to explain the sequence of events described in stanzas 1-11. Viṣṇu opens the conversation demanding a share in the Soma, before he offers his assistance to Indra for killing Vṛtra (v. 1). Indra replies and promises a share in the Soma (v. 2). But Soma alone is not sufficient to strengthen Indra for his task; so the poet asks his followers to bring forth a hymn to Indra. Yet, the poet has himself not actually seen the deities, especially Indra, even though he imagines that he has heard their conversation in vv. 1-2. He repeats what his doubting friends have often expressed to him about the existence of Indra (v. 3). Indra thereupon appears in person before him and describes his own greatness in v. 4, and in v. 5 he explains how the longings of his worshippers had reached him and how he had decided in his mind that he should appear before them in person. Vv. 6-9 now contain the stoma mentioned in v. 3, and which is required by Indra to help him in killing Vṛtra in addition to Viṣṇu's help, which latter is already secured by means of a pact in vv. 1-2. In this Stoma the events connected with the slaughter of Vṛtra are anticipated; hence, in vv. 7-9 the free movement of waters after Vṛtra's death and the Vajra's being merged in the waters of the rivers, which are brought to it as the rivers' grateful tribute, are mentioned. The Stoma itself is praised in vv. 10-11 as the best among the forms which the goddess of speech assumes and the poet concludes this praise of the Stoma with the characteristic request for gifts in v. 11*cd*. Thus having secured Viṣṇu's help in vv. 1-2 and the poet's hymn in vv. 3-11, Indra now proceeds to request Viṣṇu for helping him in killing Vṛtra (v. 12), and here the hymn comes to an end. It is more likely that the actual Stoma consists of vv. 7-9 alone, while v. 6 is merely in reply to Indra's implied inquiry about the purpose of the poet's call to him. The different metre of vv. 7-9 and their flowing simple diction confirm this supposition. V. 8 in the Stoma mentions the Soma which was brought to Indra by the hawk and which has been promised to Viṣṇu in vv. 1-2. The inversion of sequence between the events mentioned in vv. 7-9 and v. 12 is only apparent, since the Stoma in vv. 7-9 is anticipating the results as explained above.

bard, look at me; I rule over all the creatures owing to my greatness. The commands of the Rta glorify me. A breaker as I am, I break open all the created things. (5) When the lovers of the sacrifice mounted upon me, seated all alone on the top of the lovely (Soma), my mind itself said to my heart : These friends along with their children are shouting for help. (6) The poet speaks :—All these brave deeds which you performed for a sacrificer who presses the Soma, ought to be loudly praised at the libations, oh liberal Indra ; since you have flung open to Śarabha who regards the sages as his friends, the amply hoarded wealth of the distant regions. (7) The poet speaks to the Waters :—Rush forward each on her separate course ; that one who had blocked you does not now exist. Indra has surely brought down his Vajra upon the vitals of Vṛtra. (8) Going forth with the speed of mind, the hawk crossed beyond the iron fort. Going to the heaven, he brought the Soma for the wielder of the Vajra. (9) The Vajra now lies at the heart of the (aerial) ocean surrounded by waters on all sides. These continuous (rivers) whose streams are pressing forward, have brought it their tribute (namely their waters). (10) When Vāk, speaking out unintelligible things, sat down as the delightful queen of the gods, she milked out the four (kinds of speech), the nourishment, and the streams of milk ; but where indeed did her best form depart ? (11) The gods produced the divine speech ; animals of various forms speak it. May that delightful divine speech, the cow, being well praised, come to us bringing food and nourishment. (12) Indra speaks :—Friend Viṣṇu, stride afar very widely ; make room for the Vajra, oh heaven, that it may support you. Let us kill Vṛtra and set free the rivers. Being released, let them move on at the command of Indra.

Thus in brief, the hymn narrates in the form of a dialogue, how Indra first secured Viṣṇu's help by means of a pact (vv. 1-2) and then the poet's Soma by satisfying his legitimate desire to see him in person (vv. 3-11), and finally requested Viṣṇu to give him the promised help in killing Vṛtra (v. 12). Naturally the second part occupies greater space. It emphasizes the importance and divine origin of the poetic speech.

(1) *ab* : "If I go, the gods will all of them follow me to help you". The gods had left Indra refusing to help him. But Viṣṇu thinks that he may yet persuade them to follow him. This perhaps anticipates the leadership of Viṣṇu as seen in the Classical mythology. (2) *agre* : In anticipation, before the event. Cf. X. 83. 7. (3) *nemaḥ-tvaḥ* : "this or that person". (4) *pradiśaḥ* : "commands". *ṛtaśya pradiśaḥ* are the conventional laws of sacrifice. Cf. *pūrvam anu pradiśam* I. 95. 3 ; IX. 111. 3 ; *pitṛām anu pradiśam* II. 42. 2. *bhuvanā dardarimī* "I break open the created things for extracting their contents of enjoyment and nourishment". (5) *ṛtaśya venāḥ* are the longing prayers of the poets. *mā ā aruḥan* : Cf. VI. 34. 3. *b* : "I claimed the top of the lovely Soma all to myself". *haryata* is a frequent epithet of Soma. For the idea in *b*, cf. IV. 25. 6 ; VII. 98. 5. *śiśumantāḥ sekhāyāḥ* are the poets with their hymns. A hymn is often conceived as the child of a poet ; cf. in particular III. 39. 1-2. *acikradan* : Cf. IV. 24. 8 ; VIII. 3. 10 ; X. 94. 2. (6) *a* : Cf. I. 51. 13d ; IV. 22. 5b ; X. 39. 4d. Also V. 29. 13 ; 31. 6. Śarabha is some older patron of poets. The stanza grants the claim made by Indra in v. 4 and quotes the example of Śarabha in support of v. 4d (*bhuvanā dardarimī = vasu apu-avṛṇoh*). (9) *udnā abhiṛtaḥ* : The *udan* of the rivers itself is the *baḥi* brought by them to the *Vajra*. *samyataḥ* i.e., *āpaḥ*, cf. V. 34. 9. *purahprasravāṇāḥ* as against *niruddhāḥ* (in I. 32. 11). (10) *catesraḥ* : Sāyana and Geldner supply *diśaḥ* : "milked out Urj and *payāṁsi* from the 4 quarters". Oldenberg would supply *dhūrāḥ* or take it as an adjective of *urjam*. But could it not be *vācāḥ* itself? The divine Vāk produced four kinds of speech which the creatures utter (cf. I. 164. 45 c.). The fourth of these is spoken by men (I. 164. 45d). But the best of the whole lot is the divine hymn of the poet (v. 11ed). *kva vid* : "to some unknown place ; i.e., to the gods". (11) *devīm vācam* : This is the daughter; the *rāstri vāk* in v. 10 is the mother and *devāḥ* (v. 11) are the fathers. This divine Vāk namely the hymn is requested here to return to the poet as a cow, bringing her gifts from the gods, such as food and nourishment. (12) Properly equipped with a promise of help and a hymn, Indra now addresses Viṣṇu and asks him to help him in killing Vṛtra. *b* : *viśkabhe* "for support" i.e., for receiving support for itself. *hanāva vṛtram* : Cf. X. 124. 6c.

THE ĀSVINS

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VARIOUS theories have been advanced by oriental scholars regarding the nature of the *Āsvins* and their identification. Before taking up a fresh investigation into this problem it is desirable to review the most important of these theories and to state the reasons why they are found unsatisfactory. They are, therefore, arranged into the following four main groups :—

(I) The *Āsvins* represent the morning twilight—Yāska, Goldstucker, Hopkins and Myriantheus. This theory advocated by these scholars does not explain the duality of the *Āsvins*. Besides their chief function of healing or curing the diseases of mankind is not properly explained on the basis of this theory. Why the morning twilight alone has got this peculiarity is not clearly shown. The fact that the *Āsvins* are invoked to bestow genital vigour (*prajāvat retas*, cf. RV. VII, 67, 6) and are supposed to deposit germs of life within all female creatures (cf. RV. I, 112, 9) can hardly be explained in the light of this theory. Moreover, it is difficult to understand how the morning twilight can account for their intimate association with *āpah*, *madhu*, *Sūrya* and the loss of one of their chariot-wheels at the time of their marriage with *Sūryā*. At RV. X, 17, 2 the *Āsvins* are said to be the offspring of Vivasvān and Saranyū. Who these parents are and how they can be associated as parents with the morning twilight is altogether left to conjecture. Further, the twin Gods are called *Sindhu-mātara* at RV. I, 46, 2. One fails to understand how the morning twilight can be so called.

(II) Yāska mentioned another theory, viz., the *Āsvins* represent the Sun and the Moon. Hillebrandt, Ludwig and Hardy seem to advocate this theory. No doubt, the healing properties that the *Āsvins* possess can partially be explained by the Sun and the Moon theory, although it is doubtful how far the Sun and the Moon alone by themselves can effect the cure of the diseases of the mortals. For instance, how can the *prajāvat retas* spoken of at RV. VII, 67, 6, above be said to be the product created by the Sun and the Moon alone. At RV. X, 85, 9, the *Sūrya* bestowed *Sūryā* on her Lord, the *Āsvins*; how can then this *Sūryā* who is the spouse of the *Āsvins* be at the same time the spouse of the Sun, if the latter is to be identified with one of the *Āsvins* in accordance with Yaska's second theory. Further how can the *Āsvins* lose one of the wheels of their chariot at the marriage of *Sūryā* is beyond our comprehension. It is needless to point out the intimate connection of *madhu* with the *Āsvins*. How among all the Vedic Gods the Sun and the Moon should have this intimate connection with *madhu* is not properly explained by taking *madhu* in the sense of either honey or soma juice. Moreover how can the Sun and the Moon be called *Sindhu-mātara*? The chariot of the Sun is never said to have three wheels while the chariot of the *Āsvins* has got three wheels. The phenomenon represented by *Pūṣan*

is also not clearly understood if we take the *Āśvins* to be none else but the Sun and the Moon ; for *Pūṣan* is said to have chosen the *Āśvins* as his parents (cf. RV. X, 85, 14).

(III) Bollenson, Oldenberg and Manhardt understand the *Āśvins* as representing the morning and the evening stars whereas Weber and some others try to understand them as representative of the twin stars of the Gemini-Kastor and Pollux. Oldenberg's theory seems to be based on a parallel phenomenon in the Lettish mythology and the mythological figure of the Greeks. That the Dioscuri of the Greek parallel are equated with the morning and the evening stars is no proof for the assumption that the Vedic *Āśvins* should likewise be the same stars ; it is even likely that the Greek assumption or belief may not be well founded. The only conclusion that can be drawn from those parallel phenomena is that the *Āśvins* and their corresponding Dioscuri of the Greek legend might have represented some natural phenomenon even in the Indo-European period. What that aspect represented by the two Gods really might be has been neither definitely found out by the Greeks nor by the later Vedic scholars such as Yāska and others. Besides the twinship of the *Āśvins* is not properly explained and the healing properties of the *Āśvins* are hardly understood in the light of this theory ; let alone other mythological references.

(IV) The theory of Votskov that the *Āśvins* are rain Gods or the theory of Roth that they are Indra and the Sun or the theory of Bergaigne that they represent Indra and Agni—All these views must meet with the same fate just like other theories discussed above ; for none of these theories satisfactorily explains the surgical feats and magical cures that are attributed to the *Āśvins*. In fact the healing power is the main trait of the *Āśvins* which has led scholars like Geldner to think that the *Āśvins* represent some historical figures. By assuming Geldner's theory as more probable, are we then to understand Vivasvān and Saranyū, the parents of these physicians as also historical human figures and likewise consider *Pūṣan*, the child of the *Āśvins* as a historical person as well? Who is *Sūryā* in that case then ? How can we explain in the light of this theory, the loss of one of the three wheels of their chariot at the marriage of *Sūryā* ? The *Āśvins* are said to be the bestowers of rain and food unlike many other Gods. We fail to understand how human physicians can bring us rain and food. Perhaps an explanation may be offered to the effect that after these historical figures became deified, these traits were attributed to them, but this explanation is hardly convincing ; for at RV. I, 181, 4 one of the *Āśvins* is called the prince of sacrifice and the other is said to be heaven's auspicious offspring. It is very difficult to interpret such allusions in the light of the *Āśvins* as historical figures. Moreover, the fact that they are called *Sindhu-mātarā* as shown above is not in the least calculated to support the assumption that they are historical figures. Why these historical figures are specially also mentioned as *prātaryujā* or *prātar yāvāṇā* is hard to understand.

It is now pretty clear that none of the theories put forward by scholars to account for the nature and functions of the twin Gods, the *Āśvins*, can satisfactorily explain all the allusions made at different places in a number of episodes. A fresh attempt is therefore being made to probe into the mystery surrounding these twin Gods. From the discussion of various theories one thing that clearly emerges is that among all these

theories about the nature of these Twins there seem to be two schools of thoughts ; one of them which is the most popular and widely supported by scholars tries to trace all the traits of the *Āsvins* to some aspect or phase of a particular type of natural phenomenon. In fact, most of the vedic Gods are supposed to represent some natural phenomenon or other. It will be admitted that this view-point is not altogether unacceptable in view of the fact that many vedic hymns and passages can possibly be explained in the light of this assumption. The other school of thought, on the other hand, tries to explain the *Āsvins* as historical figures. But the objections raised against this point of view are so difficult to answer that one is perforce made to fall back upon the first school of thought in order to explain and interpret the concept underlying the twin Gods in the light of some natural phenomenon. The attempts so far made by the first school of thinkers have not met with any appreciable success, there being no general agreement of any sort as regards the specific aspect of nature represented by the *Āsvins* : but nature is so vast and its aspects so innumerable that a failure to interpret the *Āsvins* in the light of a particular aspect of nature does not necessarily preclude the possibility of finding a solution of this riddle by having recourse to some other aspect of natural phenomenon. At any rate one is led to believe that instead of pursuing the theory about the *Āsvins* as historical figures any longer, our attention may be more profitably concentrated on the task of explaining the chief and essential characteristics of the *Āsvins* quite cogently in the light of some aspect of natural phenomenon with the result that once these essential attributes are properly explained, other traits of the twin Gods may be easily accounted for by the process of deification of that aspect of nature. What are then the chief characteristics of the twin Gods ? The most notable that will never fail to impress the mind of even a casual reader of the *R̥gveda* is their readiness to run to the rescue of their devotees who have been ailing from some disease or other, to offer medical aid calculated to give them complete cure and to secure their general well-being and prosperity. In short they are healers par excellence.

None of the other vedic Gods are so repeatedly invoked for the sole purpose of effecting a cure from some disease or ailment ; for instance, at RV. VII, 67, 6, the devotees pray to the *Āsvins* to bestow on them genital vigour (*prajāvat retas*). The legend of *Cyavana*, an old sage, becoming again a young husband capable of meeting his youthful wife is well known (cf. RV. I, 116, 10). At RV. I, 116, 13, *Vadhrimati* obtained a child through the favour of *Āsvins*. By the grace of these twins *Ghṛā* got cured of her disease and was consequently able to marry (cf. RV. I, 117, 7; X, 40, 5). They are frequently invoked to protect the bodies (cf. RV. II, 39, 6). They possess medicines of all sorts (cf. RV. I, 34, 6). In fact, they are actually called physicians (*bhiṣajā bheṣajebhiḥ* at RV. I, 157, 6; ii, 33, 4). Quite a number of references can thus be cited to show that unlike any other vedic God, the *Āsvins* are primarily noted for their wonderful healing power. Our task now remains to search out what aspect of nature is best calculated to answer our purpose, namely to find out that natural object which possesses this miraculous healing power in a manner which baffles our imagination.

To attain this object it is quite necessary to sift carefully vedic passages occurring in the *R̥gveda* that directly or indirectly refer to the activities of the *Āsvins* as physicians of mortals and to investigate the

peculiar nature of their intimate associations. At RV. VII, 70, 3, the dwelling places of the *Āśvins* are described as situated in the fields of men, in the streams of heaven and on the summit of a mountain (*auśadhīṣu vikṣu* ; *divah yavhīṣu* ; *parvatasya mūrdhani*). In the next *ṛk* of the same *sūkta* they are said to take delight in plants (*auśadhīṣu*) and waters. Further, at RV, VIII, 9, 5, the poet implores them to succour him with whatever they have deposited or got (*kṛtam*) in the waters, trees and plants. From such passages one can clearly see that the *Āśvins* are very intimately connected with the plants and that the latter seem to play a very notable part in the sphere of their activities as physicians. In this connection the *sūkta* addressed to the plants is bound to throw wonderful light on the subject of our inquiry. At RV. X, 97, 2, the plants are said to possess a thousand powers and consequently to free a patient from his disease. That *vipra* is called *bhiṣak* who has got a store of herbs and is thus a fiend-slayer and a chaser of disease (cf. RV. X, 97, 6). The healing virtues of plants stream forth like cattle from the stall (cf. RV. X, 97, 8). Plants have driven from the body whatever malady was there (cf. RV, X, 97, 10). Again, in the 17th *ṛk* of the same *sūkta* the following interesting statement is recorded. "What time descending from the sky the plants flew earthward, thus they spoke" "no evil shall betake the man whom while he liveth we pervade". In the last *ṛk* of the same *sūkta* the trees are said to be vassals of *auśadhī*. The Atharvaveda, VIII, 7th hymn contains many interesting references to the plants and their healing properties. At AV. VIII, 7, 2, heaven is said to be the father, earth, the mother and ocean, the root of plants. At AV. VIII, 7, 4, they are described as giving life to men. Even the boar and other animals know the remedial plant (cf. AV. VIII, 7, 23). It is interesting to notice that the whole of the *sūkta* containing 28 verses contains nothing but praise of plants as healers par excellence.

The vedic passages cited above will, it is ardently hoped, go a long way in solving our problem in so far as they contain unmistakable indications about the beliefs of vedic Āryans in the medical properties of plants and their healing effect and wonderful curative power. In view of this fact it would be quite justifiable to assume that at least one of the *Āśvins* being very intimately associated with plants may be said to represent them. Vedic evidence does not invest any other natural object with such miraculous powers of curing various diseases. If at all there be any natural object serving as the basic element underlying the various activities of the *Āśvins*, according to the belief of the vedic Āryans, it is no other than the plant-life. One of the *Āśvins*, in all probability, may, therefore, represent the plants. As shown above, we find ample support for this assumption in many vedic passages and there is every reason to believe that researches in the field of science are very likely to testify the validity of this assumption. It will not, therefore, be out of place here to turn to the theory of evolution and to see whether it can throw any light on this mysterious problem. According to the generally accepted theory of evolution the plant-life is considered to be the first possible life on earth. In fact, this plant-life is made possible by the existence of *āpah*, i.e., water and light (*tejas*). It is needless to point out here how light is as indispensable to plants as water is. The animal life is the next stage in the process of evolution. Among animals almost all the animals lower than man with the exception of beasts depend mainly on plants for their subsistence. The higher type of beasts, even though they eat

flesh and live on lower animals' flesh, are indirectly dependant on plants, inasmuch as these lower animals, at least most of them, are said to have got their food from plants. In brief, plants are indeed the backbone, as it were, of the animal life. Thus plants or herbs are shown to be absolutely essential for the animal life including that of man as far as their mere food is concerned.

From the point of view of diseases and their cure treatises on the science of medicine will bear ample testimony to the healing effect and curative power possessed by plants. Taking any system of medicine one can easily see how important is the role of plants. Many lower animals that are guided by an unerring instinct chew a particular type of herb when they are suffering from some disease and are instinctively driven to it (cf. AV. VIII, 7, 23). Veterinary doctors administer some kind of medicine prepared out of herbs to these animals suffering from very acute diseases. Even in the case of men, according to all systems of medicine, it is the plants or herbs out of which finer medicines are extracted and then administered in a regulated dose, to ensure speedy recovery of a patient. The gist of this short digression is to show the great value and importance of the plant life to the animal life. One may further say that the former is at once a store-house of all essential elements that make animal life possible on earth.

So far we have discussed the importance of plant life from the point of view of food supply and cure of diseases. There is still another subtle aspect of plant life which is far more important for the healthy condition of human life on earth. It is hardly necessary here to expatiate on the indispensability of oxygen to human life. Medical experts all over the world know too well how much useful and necessary the oxygen is to the maintenance of human life and at the same time how injurious and harmful is the effect of the carbon dioxide on human life. The former stands for the life force, whereas the latter is death incarnate as far as human beings are concerned. Man inhales the former and gives out the latter. Now the very important role of plant life in the exchange of these two gases is nothing short of a miracle. A careful observer of workings of nature would not fail to detect the interplay of the plant life and the rays of the Sun unfolded by the process of production of the oxygen. The process is set into motion immediately after the rise of the Sun. During night time plants as well as human beings give out carbon, but during day time, even though human beings continue the same process of inhaling oxygen and giving out carbon, the plants, on the other hand, absorb carbon under the influence of the rays of the Sun and give out instead abundant supply of oxygen. This is technically known as carbon-assimilation on the part of plants. As said above, it should be remembered that this process starts with the sun-rise and stops with the sun-set. We will later on discuss the wonderful bearing of this aspect on the solution of our riddle, *i.e.*, the *Asvins*. For the present suffice it to emphasise the intimate relation that exists between the plants and the rays of the sun as affecting the working of human life. It will be seen from this discussion that the plant life is absolutely essential to human life; nay, in the matter of food supply and cure of diseases all living beings cannot pull on without the indispensable help afforded by the plant life. It will thus be seen that no other aspect of nature or natural phenomenon supplies the healing power as the plant life does.

One point that clearly emerges out of this discussion is that in order to solve the riddle of the *Ásvins* and their wonderful healing powers no other aspect of Nature will throw much needed light on this problem. In the critical examination of various theories about the *Ásvins* taken up in the beginning of the paper it has been abundantly made clear that the *Ásvins* do not stand either for historical figures or for some stars, but in common with most other vedic Gods they most probably seem to represent some aspect of natural phenomenon. Now to find out that aspect of nature it is needless to say that the chief characteristic of the *Ásvins* which is so conspicuously evident in the whole of Rgveda and also in the Atharvaveda and which is none else but their healing power, must be relied upon in the absence of any other help. It has been already shown above that of all the aspects of nature the only aspect that possesses this healing power is the working of the plant-life. In view of the great importance and significance of this plant-life and its relation to the animal life especially human life one has to admit the only possible alternative namely the *Ásvins* unmistakably seem to represent the plant-life. Granted that the *Ásvins* represent that aspect of nature which is called plant-life, the question remains as to why they are spoken of in the dual number, neither in the singular nor in the plural number. In other words it is necessary to explain why they are spoken of as two. May it be that the vedic Áryans had come to believe that in the art of healing besides the factor of the medical power of plant-life there was involved another factor also. The second factor in this art of healing is not far to seek if one is careful enough to use his discerning power. In our search for the second factor we have to take our clue from the healing power of the *Ásvins*, the chief and essential characteristic. From this point of view the science of therapeutics, *i.e.*, the curative art is more likely to help us in this search.

We need hardly be reminded that man is not made up of mere body—the physical aspect—but his mind and body together make up the man. The reactions of the body on the mind and that of the latter on the former demand a close study from the point of view of therapeutics. The physical aspect and the other aspect of nervous system are both to be taken into consideration before any medicine is administered to a patient. Most of the medicines and many operations of surgery are mainly concerned with the physical aspect. Medical experts' chief aim seems to restore the body to its normal condition, assuming all the while that the mental aspect *i.e.*, the nervous system and its reactions on the mind and the body are generally normal and may thus help the speedy restoration of the body to its normal state. But sometimes not only the body but the mind and with it the nervous system have suffered such a damage that the malady defies all so called medicines and the patient has mainly to rely upon his own innate will-power if at all he possesses any in such a damaged state of his health. It is generally agreed that of all the diseases those caused by the break-down of the nervous system are the most serious and depend ultimately on the patient's will to live *i.e.*, his strong faith that he would get out of that particular illness. In fact a close student of human life and its working will have little difficulty in appreciating this aspect of therapeutics, *viz.*, the strong and indomitable faith that is not easily shaken by any trifling circumstance affecting adversely the course of the disease in the process of recovery. There are a lot of cases where in spite of best medical help the expected recovery

does not take place mainly because of the absence of this unshaken belief in the ultimate recovery. In short the fact that a diseased mind presupposes a vicious nervous system and is a *death-knell*, will go to show clearly how medicine as well as the faith, *i.e.*, the will to live presupposing a sound nervous system are absolutely necessary for the recovery of a patient. The above discussion will show that in the cure of diseases, besides the administration of proper medicines, the mental factor is equally important. In other words if the plant-life which is at once the source and fountain of all human life is one factor the other factor naturally should be the psychical aspect, the indomitable will to live, the faith of the patient that he would ultimately recover in the teeth of various odds that may temporarily warp his mind.

It would be advisable as well as necessary here to examine vedic evidence and to see how far it supports the second part of our thesis, *viz.*, faith or *bhāvanā* of a patient may be represented by one of the *Āsvins*, the other member being already shown to represent the plants. It must be admitted that vedic evidence is not so strong in this respect as in the case of plants. Nevertheless in a *sūkta* addressed to *śraddhā* (cf. RV. X, 151) the importance of faith in general especially in all sacrificial acts is brought out. In many *sūktas* addressed to the *Āsvins* references to the mental factor are a special feature which is not so conspicuously seen in the case of other vedic gods. For instance the horses of the *Āsvins* are called *manojuhā* (cf. RV. V, 75,6); their chariot is yoked by the mind (*manasā yuktā* cf. RV. VII, 69, 2) and is also called *manojavā*, *i.e.*, as quick as the mind (cf. RV. I, 117,15; V, 77, 3). At RV. VI, 62, 3, they are said to carry thoughts with their horses and are themselves called *manotarā* (cf. RV. I, 46, 2). They won over or drew towards them the mind of *Dadhyañ* and then the horse's head uttered his words to them (cf. RV. I, 119,9). The ignorant does not know how to worship the *Āsvins* especially the mortal who has no spirit or will power (cf. *akrayamāte* at RV. I, 120, 1 and 2). At RV. VIII, 86, 2, a question is raised as to how a mortal who is *vīmanā* can praise the *Āsvins*. These passages from the *R̥gveda* may be taken as a tolerably good piece of evidence establishing the importance of the mental factor, *i.e.*, faith as an integral part of the activities of the *Āsvins*; for instance, in the case of *Dadhyañ* in the passage referred to above the co-operation of his mind or will power was required to effect the ultimate result. Moreover in the last two passages, *viz.*, RV. I, 120, 1, and 2 and VIII, 86, 2, it is clearly implied that a mortal who has no will power or *bhāvanā*, *viz.*, faith in the healing power of the *Āsvins* will fail to propitiate them and thus to obtain from them sound health and prosperity. Further, it has already been shown above that throughout its history medicine has employed two main types of therapy, *viz.*, the influencing of the body by the mind and the influencing of the body by physical remedies and that these methods have not been mutually exclusive (cf. *A Short History of Science*, by Dr. Taylor, p. 15). We have thus been able to see that of the two factors that govern human life, namely the physical aspect *i.e.*, the body and the mental one, *bhāvanā*, the plant-life which is mainly concerned with the recovery of the body is represented by one of the *Āsvins* and the other *i.e.*, mental aspect is represented by the second member of the *Āsvins* and that just as these two aspects of human life are inseparably connected exactly so are the two *Āsvins*.

After solving the riddle of the *Āśvins* thus in a rather unexpected manner, it remains for us to explain other traits of this divine pair. Here at the outset before this further inquiry is undertaken one must get certain other important points cleared up. Judging from the Indian or Āryan point of view human life is not only governed by the plant-life and its inseparable counter-part, *i.e.*, the mental energy but by other factors as well. In fact life in every form on this earth is governed by the forces of other planets in the solar system. Our earth being a part within the orbit of the solar system it is but natural that the forces exerted on earth by other planets of the system and the sun in particular ought to count a good deal in the working of earthy life. It is likely that some people led away by the opinions expressed by some scientists may erroneously consider this exposition as unscientific as it is based according to these people, on astrology. Yes, it may be called astrology if we were to interpret these facts in terms of good or ill luck to persons affected by this phenomenon. Our attempt here is, however, not to measure the influence of these planets on earthy life in terms of astrology, but to state the fact that the planets do exert influence on one another, which is a scientific fact. Let it be remembered that the influence of these different globes on one another is admitted as due to the force of gravitation. Besides the fact that the moon is the immediate cause of tides in the oceans and that the sun's influence on all earthy life is an accepted proposition will further go to prove the validity of the view-point stated above. At least the vedic Āryans believed in the influence of these planets. That is why a particular auspicious hour, month or day was chosen by them for the performance of a sacrifice. A particular conjunction of the sun and the moon with certain *nakṣatras* was considered by them as very helpful for an important undertaking. Scientific researches have proved that plant-life is immensely influenced by the rays of the sun. Next to the sun in importance is the position of the moon in the solar system and its influence on plant-life and the epithet *oṣadhinam pati* given to the moon is very significant from this point of view. In the solar system next in importance to the moon are two other planets *viz.*, the Jupiter and the Venus. Even to a naked eye their brilliance is visible. It is quite natural, therefore, that the vedic Āryans should concentrate their attention more on these three planets and come to believe in their influence on other planets especially on the earth.

In view of this general discussion about the solar system and its influence on the earth especially on plant-life, one may be able to understand how the *Āśvins* representing the plants and the faith or *bhāvanā* of the mortals are intimately associated with the sun. At RV. I, 22, 1, they are called *prātar yujā*. Savitar sends before dawn the car of the *Āśvins* (cf. RV. I, 34, 6). They equip their chariot for the course in the morning (cf. RV. I, 157, 1; X, 40, 1). These passages show that the proper function of the *Āśvins* starts at the sun-rise. From the discussion that we had above about the process of carbon-assimilation and the supply of oxygen to the mortals on the part of plants, one will clearly see how the influence of the *Āśvins* begins to operate after the rise of the sun. The name of the twin gods is likely to be derived from the *Āśvini nakṣatra* for during the period of that *nakṣatra* the plants are said to attain their exuberant growth according to a common belief in India. The mutual inter-action due to the force of gravitation of different planets of the solar system exerting their influence on earthy life may

most probably therefore be said to constitute the so-called chariot of the *Āsvins*. The three wheels of this chariot (cf. RV. V, 73, 3) may perhaps be the three bright looking planets, viz., the moon, the Jupiter and the Venus. The invisibility, either partial or complete, of the bright looking Venus after the rise of the sun may then symbolically stand for the loss of one of the chariot wheels at the marriage of *Sūryā* (i.e., the rays of the sun) with the *Āsvins* (i.e., the plants). The parents of the *Āsvins*, viz., *Vivasvān*, their father and *Saranyū*, their mother are naturally none else but the sun and the earth in so far as the plant-life being represented by one of the *Āsvins* and *bhāvanā* of mortals being represented by the other *Āsvin*. God ultimately owe their origin to the inter-action of the sun and the earth. This fact may further explain how the vedic God *Puṣan* can aptly be called the offspring of the *Āsvins*. (cf. RV. X, 85, 14) for *Pūṣan* is probably the deification of the feeding factor (i.e., nourishment) concerning mortals and as such is the outcome that can be traced to the influence of plants on mortals. Solar phenomenon can also account for the marriage of *Sūryā* with the *Āsvins* (cf. RV. IV, 43, 6; I, 119, 5, VII, 69, 4) inasmuch as the rays of the sun endowed with wonderful medical properties being the main cause of various colours become more effective when they come into close contact with the plants. *Sūryā*, therefore, stands for the former while the latter are represented by the *Āsvins*. The exclusion of these twin gods for some time from the circle of soma-drinking gods can probably be explained by the fact that they must have been considered impure on account of their close association with diseased mortals as doctors or physicians even today are so considered by orthodox people. But later on they came to be included into the circle of gods owing to their close association with the Soma plant. In fact at RV. X, 97, 18, the latter is called the lord of all plants and is said to possess the combined virtues of all plants (cf. RV. IX, 114, 2). At RV. I, 181, 4, one of the *Āsvins* is called the prince of sacrifice while the other is said to be the offspring of heaven. Evidently by the former we have to understand the plants including the *soma* and then *bhāvanā* or faith may naturally be considered as divine and thus stand for the latter. Further the twin gods are rightly called *Sindhu-mātarā* since the plant-life owes its origin to water.

We have thus tried to explain the main ideas and figures associated with the phenomenon of the *Āsvins* and confidently believe that almost all the legends illustrating the healing and helping power of these twin gods can be satisfactorily explained in the light of this theory based on vedic evidence and corroborated by the most mysterious role of plants and faith affected in a marvellous manner by the solar phenomenon in the field of therapeutics.

SOME SYMBOLICAL LEGENDS FROM THE FIRST KĀṆḌA OF THE ŚATAPATHA BRĀHMAṆA

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IT is admitted by all students of Vedic Literature that the Authors of the Brāhmaṇas are adepts in the art of using symbols. It is through these symbols that they seek to communicate the various items in the sacrificial procedure. This pompous and regular use of symbols to explain their sacrificial procedure is not without any purpose behind it. The authors of the Brāhmaṇas rightly thought that if they were to communicate any item or part of the sacrificial procedure in a "dry-as-dust" manner it would neither be understood nor be strictly adhered to by the followers of the sacrificial cult. They, therefore, realised the necessity of conveying information about the various sacrificial items in a manner that was simple and interesting without at the same time sacrificing their immediate purpose in view viz., to make the use of the sacrificial ceremonial obligatory on the part of all and sundry followers of their cult. For this purpose they devised the means of symbols and symbolical narratives—especially the latter. This would explain at once the presence of an enormous mass of symbolical narratives in the body of the Brāhmaṇas. All these symbolical legends can be said to be stories particularly invented for carrying on propaganda for the spread of sacrificial cult and as such they could be said to be the predecessors of the *Jātakas* of the Buddhas and the religious stories of the Jains. The Brāhmaṇas, of course, have not as much exploited the art of narrating a story as the later propagandists have done. The art of story-telling or story-writing was absolutely in a germinal stage and the authors of the Brāhmaṇas used it for their immediate purpose. They did realise the distinct advantages of this art for carrying on religious propaganda and they made the best of it. The Brahmanic legends, however, do not respect the technique of a short story. They are far from it. One should not expect them to do so. These stories are primitive in form and ought not to be judged by the standards of a modern short-story. At the same time they fulfil their own purpose viz., explaining or giving information about sacrificial items individually or collectively. In a sense, then, these legends are "aetiological" narratives because they purport to explain some purpose. Most of the Brahmanic stories, as stated above, are symbolical tales though interspersed here and there we come across legends that can be styled "Moral Tales" or "Popular or Historical Narratives." Some of the innumerable symbolical narratives of the Brāhmaṇas explain the whole of the sacrificial ceremonial: others elucidate only a part of a specific ritual: still others explain the derivation of a word, a phrase or a name, etc., mediately or immediately connected with the ceremonial under review; while there are other narratives that try to explain the use and purpose of a particular *mantra* that happens to be recited during the sacrificial cere-

monial. In the present paper are discussed eight symbolical stories from the First Kāṇḍa of the Śatapatha Brāhmaṇa in order to show how they fulfil one or the other purpose referred to above.

The ceremony of *apām-praṇayana* is explained in the following Legend.¹ There are various reasons given to explain this ceremony. (1) The waters are, verily, the sacrifice. So, when by his first act in the morning the Adhvaryu brings the waters forward he approaches the sacrifice *i.e.*, he engages himself in the sacrifice. (2) the Adhvaryu brings the waters forward with the mantra "*Kas tvā yunakti sa tvā yunakti Kasmai tvā yunakti tasmai tvā yunakti.*" These are certainly mysterious words (*anirukta*). Prajāpati is *anirukta* (undefined or mysterious). Prajāpati, again, is the sacrifice. When the sacrificer brings the waters forward with the mysterious formulae he as it were gets the sacrifice ready for Prajāpati. (3) All this is pervaded by the waters. So, when he brings the waters forward by his first act in the morning, he pervades or gains the Universe. All that the sacrificer does not succeed in accomplishing is achieved by him when the Adhvaryu carries the waters forwards for him. The Brāhmaṇa is not satisfied after adducing these reasons for performing the ceremony of the "*Apām-praṇayana*". It therefore narrates a legend to elucidate the purpose of this ceremonial. The legend refers to the oft-mentioned strife of the gods and the Asuras.

I "The gods were engaged in performing a sacrifice. The Asuras intimidated them in their pious activities, saying, "*na Yakṣadhva,*" etc. "Ye shall not sacrifice". Because the demons forbade ($\sqrt{\text{raks}}$) they are called *rakṣas*.² Since the Asuras thus interfered with their pious activities the gods searched for a means by which they could drive the Asuras away from the scene of their sacrifice. The gods, while carrying on their vigorous search, perceived the thunder-bolt. The waters are, indeed, the thunder-bolt for wherever they travel they create a ditch or a hollow (*ninna*) and whatever they come across they destroy like the thunder-bolt. The gods, raising this thunder-bolt and brandishing it against the Asuras could finish their half-finished sacrifice in a foe-less, safe place. Thus, the Adhvaryu, by bringing the waters forward at the beginning of the sacrifice raises the thunder-bolt against the enemies of the sacrificer and performs the sacrifice in a safe place free from evil influences. The sacrificer performs the sacrifice without being intimidated by evil agencies from out-side.

The water used for sacrificial purposes is to be strained or purified with the two strainers. The reason for doing so is contained in the following legend³ which refers to the Indra-Vṛtra fight the basis of which we find in the hymns of the Ṛgveda.

II Vṛtra, once upon a time, covered the entire space that lies between the heavens and the earth.⁴ Indra, however killed him with his thunder-bolt. He became putrified⁵ and flowed, in all directions

¹ SBR. I-i-1-9.

² Note the derivation of the term *rakṣas*.

³ SBR. I-i-3-4-5.

⁴ *Sa yad idam sarvam vṛtvā śiṣye tasmād Vṛtro nāma.*

Note the derivation of the name Vṛtra. Vṛtra is derived from $\sqrt{\text{Vṛ}}$, to cover.

⁵ *pūtiḥ* = *durgandniḥ*.

into the waters. In consequence of this some of the waters became disgusted and flowed over the putrified Vṛtra, rising up. The unputrified waters that flowed over the putrified Vṛtra, rising up, became the *darbha* grass but in the other waters that did not or could not flow over the putrified Vṛtra some putrid matter became mixed up inasmuch as the dirty demon Vṛtra flowed into them. The water used for sacrificial purposes may be from these dirty waters. The priest removes the unclean matter from the waters by straining it with the two strainers.

The skin of the black antelope is to be put on for the completion of the sacrifice. SBR. I-i-4-1 narrates a legend to explain why the skin of the black antelope alone is to be put on.

III The sacrifice once escaped from the gods and roamed about having assumed the form of a black antelope. The gods having learned about the escape of the sacrifice searched for it vigorously. They found it roaming about in the form of a black antelope. They stripped its skin off and brought it (skin) with them for the completion of the sacrifice. The sacrificer also puts on the skin of the black antelope for the completion of the sacrifice.

The legend incidentally speaks of the importance of the skin of the black antelope. It may be regarded as the symbol of Brahmanical worship and civilisation. Manu (II. 22-23) indirectly refers to the importance of the black antelope. "That which lies between these two mountain ranges (The Himalayas and the Vindhya) from the Eastern to the Western Ocean, the wise know as *Aryāvarta* (the land of the Aryas). Where the black antelope naturally roams about that should be known as the land suitable for sacrifice. What lies beyond that is the country of the Mlecchas or the Barbarians."

The *Haviṣkṛt*¹ gets up and beats the two mill-stones with the *śamyā*—a stick of Khadira wood usually six or eight inches long. A discordant noise is being produced while the mill-stones are being beaten with the *śamyā* by the *haviṣkṛt*. SBR. I-i-4-13-17 offers an explanation for this discordant noise by narrating the following legend.

IV Manu had a bull in whom entered the asura-killing, foe-killing speech.² Whenever, therefore, the bull snorted and roared the asuras and the *rākṣasas* were crushed. They held a parley and thought of finding a way out to do away with the bull of Manu. *Kilāta* and *Ākuli*³ were the priests of the Asuras. They thought of exploiting the God-fearing nature of Manu. They approached him and expressed their desire of sacrificing for him. Manu could not refuse. On being asked

¹ According to Kātyāyana either the wife of the patron or the Agindhra priest acts as *haviṣkṛt*. Mahidhara includes the patron or the sacrificer himself. According to Apastamba either a maid-servant or the wife of the sacrificer grinds the corn or the wife thrashes the corn and the Śudrā grinds it. Opinions differ as regards who should act as the *haviṣkṛt*. Similar cases of differences regarding ritualistic practices at different times are frequently attended to in the ritualistic literature. They are of special interest to us as they afford some insight into the gradual development of and subsequent changes introduced into the sacrificial ceremonial.

² *asuraghñi śapatnaghñi vāk*.

³ The priests of the Asuras are many times referred to by names in the Brāhmaṇas. These references may suggest that the Asuras had their own sacrificial code, rather different from that of the Suras or the gods.

by him as to with what were they going to sacrifice, they said, "With your bull". Manu agreed and the bull was sacrificed. On the bull being killed, the foe-killing, asura-killing speech entered the wife of Manu, Manāvi by name. To their complete amazement the Asuras realised that a greater evil was now facing them for whenever Manāvi spoke the Asuras were killed. Surely, the human being speaks all the more frequently.¹ Kīlāta and Ākuli approached Manu again and repeated their desire to sacrifice for him with his wife. The pious Manu gave his consent even to such a sacrifice wherein his own wife was to be the victim. The wife of Manu was killed and the foe-killing, asura-killing speech entered the sacrifice itself. The priests of the Asuras could not drive it from there. This same asura-killing, foe-killing speech sounds forth when the mill-stones are being beaten with the wedge by the *haviṣkṛt*. When, therefore, the discordant voice is produced at the time of grinding corn the enemies of the sacrificer as well as of him who knows this are completely crushed.

For the preparation of the Vēdi or the sacrificial altar the priest has to use the wooden sword or the *sphya*. SBR. I-ii-4-1-2 states a legend to indicate the *vajra-rūpa* of the *sphya* and the *yūpa* or the sacrificial post along with it.

V. When Indra hurled his *vajra* against Vṛtra it became four-fold. The *Vajra* represents one-third of it, the *Yūpa* one-third and the *Ratha* one-third. The piece with which he struck Vṛtra was broken off ($\sqrt{\text{ṣṭ}}$) and on falling down it became an arrow (*Śara*)². As the *sphya* and the *yūpa* are *vajra-rūpa* the Brahmins³ use them in the sacrifice. The Kṣatriyas³ use the *ratha* and the *śara* in battles for similar reasons.

The winnowing basket and the Agnidhra-ladle are to be beaten symbolically with the formulae "*pratyūṣṭam rakṣaḥ pratyastā arātayo or niṣṭam rakṣo niṣṭaptā arātayah*." A legend narrated at SBR. I-i-2-3-4 explains the purpose of repeating this mantra.

VI While the gods were performing a sacrifice they were afraid of some disturbance from the Asuras. The gods destroyed the Asuras as a result of the merit that accrued to them from the performance of the sacrifice. Thus, when the aforesaid mantra is repeated by the priest the demons or the enemies of the sacrificer are destroyed at the beginning of the sacrifice.

SBR. I-ii-4-16 gives the whole process of digging the ground and throwing away the earth to the accompaniment of certain specified mantras. The *sphya*, for instance, is to be thrown with the mantra, "*apārarum pṛthivyai devayajanād badhyāsam*." To state the purpose of repeating this specific holy text a short legend is narrated in this section.

¹ Does this refer to the prattling nature of the human beings, particularly of the members of the fair sex?

² Note the derivation of the word *Śara*. Since the part of the *Vajra* with which Indra struck Vṛtra was broken off and it fell down, it is called *Śara*.

³ Here there is a reference to two Castes only because they dominated in the Vedic Society.

VII Araru was a demon whom the gods drove away from the earth which was the gods' place of worship or the *devayajana*. Thus by repeating this *mantra* at the time of flinging the *sphya* the Adhvaryu drives away the Asura-rakṣas Araru from the place of worship on behalf of the sacrificer.

The Agnidhra-priest whilst pressing the earth so dug by the Adhvaryu on the *utkara* or the heap of rubbish utters the *mantra* "*Araro divam mā pāpta*," etc. The significance of this *mantra* is also stated in a short legend at SBR. I-ii-4-17-18.

VIII. This Asura-rakṣas Araru, when he was driven out of this earth by the gods, desired to fly to the heavenly world. Agni pressed him down saying "*Araro, divam mā pāpta*." The Agnidhra-priest also presses this Asura-rakṣas down and prevents him from reaching the heavenly world when he presses the "dug-out" earth on the *utkara* with the *mantra* referred to above.

It will be clear from the fore-going summary of the legends that the legends have been particularly invented to explain or account for matters connected with the sacrificial ceremonial. Thus, the first legend explains the propriety of performing the subsidiary rite of the *apām-pranyana*. The second accounts for the priestly action of straining the water with the two strainers: the third states the reason for putting on the skin of a black antelope by the *Yajamāna* during the sacrificial performance: the fourth explains the significance of even a minor phenomenon like the discordant noise produced at the time when the mill-stones are beaten with the *śamyā*: the fifth states the propriety of using the *sphya* or the wooden sword at the time of preparing the *Vedi* or the sacrificial altar and legends VI—VIII bring out the significance of repeating specific *mantras* or holy texts on particular occasions. Collection of all the symbolical legends scattered throughout the Brahmanic literature will, indeed, be interesting. They will throw light upon the inventive power or faculty of the Authors of the Brāhmaṇas who never failed to explain even the minutest detail of the sacrificial ceremonial symbolically. The present paper is just an attempt to emphasise this predominant characteristic of the Brāhmaṇas on the evidence of the legends occurring therein.

ILLUSTRATED MSS. OF BILVAMAṄGALA'S BĀLA-GOPĀLA-STUTI

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THE early Vaiṣṇava miniatures of the "Kṛṣṇa Bāla Carita" or the "Bilvamaṅgala-Stotra" so far popularly known as "Bālagopāla-stuti" by Bilvamaṅgala in the Gujarātī style are now found to exist in as many as six¹ different series. They are all painted in one style with certain variations. Thus they go to establish without any further doubt the prevalence of a popular general style of miniature-painting in the geographical area situated in Western India, mostly Gujarāt of pre-Mughal boundaries, without allegiance to any creed or religion.²

The text of the Mss. of Bilvamaṅgala's several "stotra-graṇthas" like the "Bālakṛṣṇa-carita" seems to be unpublished and have not been fully examined, although on comparison with the *Kṛṣṇa Karṇāmṛta* printed in the Vāṇi Vilāsa Sanskrit series (1929) generally styled as the



1. Male Study



2. Male Study

¹ This includes the one recently acquired by N. C. Mehtā, Honorary Director, Art Section, Bhāratiya Vidyā Bhavan, Bombay.

² Cf. "Works of painting, pronounced 'secular,' in subject, as the illustrations of 'Vasanta Vilāsa' or 'Rati Rahasya' do not differ in form from the mode in which religious manuscripts of the same zone and age are illustrated. There is no distinction in their form between the two as there is no separation of religion and daily life, but one consistent mode of being, which is present in both."

—"Theory of Art," being the Presidential Address, by Dr. Stella Kramrisch, IX All-India Oriental Conference, Fine Arts Section, Trivendrum (1937), Proceedings, p. 1036.

South Version of the text comprising about 312 verses, one finds that about more than half of the bulk from the Mss. is scattered over the printed and Mss. collection of hymns ascribed to Līlā-Śuka or Bilvamaṅgala, the well-known Vaiṣṇava saint sometimes styled as "Jayadeva of the South." He though hailing from South India (Tirunavay, British Malabar) was born at Puttañcira in the taluk of Parur in North Travancore, according to U. S. Parameśvan Iyer, travelled widely and was one of the first pioneers of the development of devotional Vaiṣṇavism.

Bilvamaṅgala Swāmi, it is surmised, lived sometime between A.D. 1220 and 1300. The name of his mother and father were Nīli and Dāmodara respectively, according to a verse in the Kṛṣṇakarnāmṛta. By the end of the 13th century his Vaiṣṇava hymns must have gained currency throughout India, including Gujarāt as did a verse from Jayadeva's *Gītagovinda* in the 13th century A.D., (in Samvat 1348)⁸ so that in the early part of the 15th century illustrations of his hymn, such as offered by these illustrated Mss. must have been in request in Western India, especially in Gujarāt of those days. Gujarat with its famous pilgrim-centres of Prabhāsa Paṭṭana and Dwārakā, intimately connected with the cult of Kṛṣṇa has long been associated with various forms of Vaiṣṇavism.

After a close scrutiny of the text of the "*Bālagopāla Stuti*"—especially—from the colophon after verse 108 on folio 21 it seems very likely that it may have been an anthology of verses bearing on the life of Child Kṛṣṇa compiled and strung together by Swāmi Bilvamaṅgala. Hence it may be that these apocryphal collections of Kṛṣṇa-verses have been ascribed to him. Several of the verses included in the southern version of the "*Kṛṣṇa-karnāmṛta*" have been traced to different sources and some of them might have formed a part of the floating literature of the type of "*Subhāṣitas*" glorifying the devotion towards the sports of Bālakṛṣṇa of the Gokula and Brindāvana days, and others are traceable to the



3. Male Study



4. Male Study

⁸ Vide Stone-inscription reproduced in the Journal of the University of Bombay, May 1938, in "A 15th Century Gītagovinda Mss, with Gujarāti Paintings."



5. Couple Study



6. Female Study

“Bhāgavata,” the “Mukundamālā,” the “Daśakumāracarita” and the “Rāmāyaṇa campū.”

The verse, for example, referring to the showing of the three worlds in the open mouth by Kṛṣṇa to Yośodā, ‘बृहणेनाम्ब गनेन रत्नमुधुना मुद् भक्षिता स्वेच्छया’ has been referred to by Kṣeṃendra (Circa 9th century A.D.) (Plate I) in his “*Aucitya Vicāra Garcā*” (Kāvya-mālā, Part I, p. 130) while illustrating *adbhuta rasa*, as being a verse by one *Candraka*.

Another verse illustrating the *rāsa-kriḍā*,⁴ and forming one of the eight (*aṣṭaka*) verses describing the dance⁵ of Kṛṣṇa with the Gopis, with graceful movements and rhythmic gestures of the limbs has been referred to in the commentary called “*Subodhini Bhāṣya*” on the “Bhāgavata” by Vallabhācārya (1479-1533 A.D.) as (Kasyāpi) somebody’s. This fact suggests that the authorship of the verse was considered to be unknown even to Vallabha.

Illustrations of the verse “*bibhrat venum jatharapaṭayoh*” etc., from the Bhāgavata (Skandha 10, Adh. 13 verse 11) are found in all the illustrated copies of the Bālagopāla-stuti. (Plate II).

Also बह्नीपीडं नटवरवपुःकर्णयोःकर्णीकारं etc. (Daśama Skandha Adh. 21, verse 5) is common in these series (Plate III).

The colophon on a folio of the Mss. after verse 108 “इति श्री परमहंसप्रज्ञा-जकाचार्य श्रीपाद बिल्वमंगल विरचिता श्री बालगोपाकस्तुति : इतिमाष(व)पुराणे भगवद्वाक्यम् ॥ १०८ ॥ ॥” seems to suggest that the text of this Mss. formed a part of an anthology of Vaiṣṇava hymns, in which this section found an honoured place, as recording the word of the Lord himself. (Plate I). It is suggested that माषपुराणे might have been a slip for ‘माधवपुराणे’ by the scribe.

⁴ See Dr. S. K. De's edition of ‘*Kṛṣṇa-Kaṇṭhāṣṭa*,’ Appendix I, verses 35-42, p. 312

⁵ “अंगनामंगनामन्तरे माधवो । माधवं माधवं चान्तरेणांगना ॥

इत्थमाकल्पिते मण्डले मध्यगः । संजगी वेणुना देवकीनंदनः ॥”

For illustration, see my paper in JISOA, 1942 ‘Some Newly Discovered Vaiṣṇava Miniatures,’ Plate I : (miniature enlarged).

All the illuminated Mss. of the "Bālakṛṣṇa-carita" evidently copied in western India, appear to follow the Southern recension of *Kṛṣṇa-Karṇāmṛta*, which gives about 319 verses in three sections; they differ from the Bengal recension of the KK. which consists of 112 verses only.

The tradition existing in Kerala, the place of origin of KK. is that it comprises only 303 verses as is evident from the following verse found in old Mss. :

‘कर्णामृतं भगवत्स्वरितं रसज्ञः । श्लोकत्रयाधिकशतत्रयमादरेण ॥
शृण्वन् पठन्ननुदिनं समुपैति सिद्धिः । सिद्धो यथा सकललोकविहाररूपाम् ॥’

Nevertheless, the Kerala-pāṭha itself consists of 336 verses. The Āndhra version is different from the Keraliya and is made up of 329 verses. The extent of verses in "Bālagopāla Stuti" Mss. appears to be beyond 369 in an incomplete Mss. introduced through this paper.

Verses of other authors, some known and some unknown, went into the making of the "Bāla Kṛṣṇa Kṛīḍā Kāvya" and have swelled its original bulk. But it is also possible that the texts, prevailing in southern and western India, were not merely imitative supplements deliberately composed in their entirety by some later authors and tacked on the original text. Their nucleus might have been drawn from verses occurring in other "Stotra"—like works composed by or ascribed to Bilvamaṅgala, such as the "Viṣṇu stuti," "Sumaṅgala stotra," "Kṛṣṇabālacarita," "Vāsudevastotra" etc., and around this might have been woven verses of less known writers which, with their authorship forgotten, came to be amalgamated with the genuine verses of Bilvamaṅgala.

The Bengal tradition of the *Kṛṣṇa-Karṇāmṛta* (limited to 112 verses only) appears to have originated from the time of Caitanya (1486-1533 A.D.), who is reported to have discovered and brought the "Kṛṣṇa karṇāmṛta" Mss. from his pilgrimage in southern and western India and introduced it to his followers; and from his time, it became one of the sources of the religious inspiration of Bengal Vaiṣṇavism. It may be that the Mss. he came across might have been fragmentary, as several incomplete copies of popular works are not unknown. Caitanya is



7. Female Study



8. Female Study



9. Female Study



10. Female Study

said to have been so moved by its devotional value that he not only commended it in superlative terms to his disciples, but it also became one of the main springs of his own religious experience. It certainly exercised, along with Jayadeva's "Gīta-govinda," great influence on the emotionalism of the Bengal Vaiṣṇava faith. It inspired similar lyrics and was quoted as authoritative in the treatises on "*Bhakti-rasa-śāstra*" composed by Rūpa Goswāmin and others. Several commentaries such as the "Kṛṣṇa-Vallabhā," the "Subodhinī," and the "Sāraṅgarāṅgadā," came to be written on it, as on the '*Gīta-govinda*,' by the Bengal Vaiṣṇavas, explaining its esoteric religious significance.

The local traditions in the south do not agree about Līlā Śuka-Bilvamaṅgala's place of birth and activity, and many regions claim him ; but the question is only now being investigated.⁶ His date is almost certain, although Winternitz (who suggests that the title of the work may be 'Kṛṣṇa-līlāmṛta') would place Līlāśuka in the 11th century; but M. Rāmakṛṣṇa Kavi⁷ gives the outside limits of his date as 1060 and 1350 A. D., limiting it further to a period between 1250 and 1350, chiefly on the ground that Bopadeva, who flourished about 1250 A. D., is one of the latest writers quoted in the grammatical works, ascribed to Bilvamaṅgala. Rāo Bahādur U. S. Parmeśvara Iyer has fixed up 1220-1300 A.D. as the life-time of Bilvamaṅgala Swāmi.

There is a tradition preserved by the followers of Śrī Madhvācārya (1199-1295 A.D.) that he had a favourite disciple of his, known as Bilvamaṅgala. Ācārya's every completed work concluded with विरवमंगलः सप्तु (Vide Kumabhakoṇam Edition of Śrī Madhva's works).

This Bilvamaṅgala was Līlā Śuka, the author of KK. for the following reasons: The Ācārya was a devout worshipper of Śrī Kṛṣṇa whose temple he established at Udipi, and sang of his glory in soul-stirring hymns known as the द्वादशस्तोत्र. Madhvācārya is the author of कृष्णामृतमहाणव, which exalts devotion to Viṣṇu and prescribes the rituals of his worship. Līlā Śuka, very likely, sang the glories of Śrīkṛṣṇa in कृष्णकर्णामृत naming it in imitation of Guru's work.

⁶ See "Bibliography on Bilvamaṅgala and his Works" at the end of this paper.

⁷ Journal of the Andhra Historical Research Society, Vol. III, July 1928, pp. 66-71.

The very surname of Līlā Śuka of the poet, is an evidence of the Bhāgavata cult introduced by Madhvācārya in the West Coast, the title having been awarded by the Guru owing to the fervid devotion to Śrī Kṛṣṇa recalling Śukamuni's love of the Bhāgavata.

These cumulative evidences tend to the identification of Līlā Śuka with the second Bilvamaṅgala, and therefore his date might be the middle of the 13th century A.D.⁸

One Gadādhara Dāsa, the disciple of Viṭṭhalanāthji, the second son of Vallabha (1535—1589 Samvat) records in his work "*Sampradāya-pradīpa*" (composed in Samvat 1610), a tradition about Bilvamaṅgala, according to which there were three Bilvamaṅgalas, one⁹ in the South, Dravidian, another in Benares and the third one in Utkala, who is said to be the author of a *stotra* of 108 verses¹⁰; Līlā-śuka and Bilvamaṅgala were identical, it is argued on the strength of an old Mss. of 456 verses



11. Female Study



12. Female Study

⁸ See "Bilvamaṅgala Līlā Śuka : His Date and Identity," by Prof. V. Rāghavendra Rāo, Proceedings, Indian History Congress, IX Sessions, Annamalai University, 1945 (Published in May 1947).

⁹ Another tradition regarding three Vaiṣṇava devotees under the common name of 'Bilvamaṅgala' has been noted by Ū. S. Parmeśvara Iyer in Proceedings of the IX Oriental Conference, Trivendrum, 1937, on p. 471.

¹⁰ "अथ श्री विष्णुस्वामिसंप्रदाये बिल्वमंगलनामा बभूव । बिल्वमंगलौ द्वावभूतौ । उत्कल-देशे तृतीयश्च । यस्याष्टोत्तरशतश्लोकसंख्याकं स्तोत्रं श्रूयते । एकः काश्यां एको द्राविडे च । द्राविडदेशीयो विष्णुस्वामिसंप्रदायी । काशीवासी द्वितीये जन्मनि जयदेवनामा बभूव । येन श्री गीतगोविंदगानं कृतं । प्रथमे माधवानलः । द्वितीये जन्मनि बिल्हणः । तृतीये बिल्वमंगलः । चतुर्थे जयदेवः । कामकंदला शशिकला काश्यां वेदया चिंतामणिः । पद्मावतीति क्रमादाराध्य श्री गोपीजनवल्लभाख्ये तत्त्वे द्वयोरपप्येकमस्यं । बिल्वमंगले विष्णुस्वामि मार्गे प्रशासति-तच्छिष्यः इत्यादि ।"



13. Female Study

in the Kānkaroli Vidyābibhāga collection, wherein Bilvamaṅgala is mentioned as the author in the beginning.¹¹

It is significant, however, that one Gujarātī poet from Prabhāsa Paṭṭana, (Kāthiāwār), Keśava Hṛdayarāma, who composed “*Sri Kṛṣṇa Līlā Kāvya*”¹² an adaptation of the 10 th Skandha of *Bhāgavata* in Samvat 1529 (1463 A. D.) has incorporated three verses, traceable to the *Kṛṣṇa Kaṇāmṛta* (K. K. II, 54; K. K. II, 64; K. K. II, 78) in his work along with similar quotations from the “*Bhāgavata*” and the “*Pāṇḍavi Gītā*.” This fact points out that the verses of the second “*Śataka*” as found in the southern version, were known in Western India and Kāthiāwār even early in the 15th century, and even before Lord Caitanya’s birth, who had later visited Dwārakā. Accordingly, it cannot be asserted with certainty, (as is done by Dr. S. K. Dé in his edition of the “*Kṛṣṇa Kaṇāmṛta*”) that the first “*Śataka*” alone brought by Caitanya from the south was the only genuine text, and that the other two sections so well-known in western India were later interpolations by unknown anthologists. This contention has found support on other grounds from K. Kunjunni Rājā from his paper on the Text-Problem of “KK” (IHQ. XXII). However, we can concede so far, that as recorded in the “*Sampradāya Pradiṭṭa*,” at least there was one Bilvamaṅgala of Utkala who was reputed to be the author of a “*stotra*” of 108 verses only. It is quite possible also that the texts of Bilvamaṅgala’s Stotras were not entirely free from interpolations and were subject to the fate of all the popular works of the “*śatakas*” type.

Two more works in Mss. but without any illustration entitled “*Kṛṣṇa-bāla-carita*” and “*Bāla-kṛṣṇa-kṛīḍā-kāvya*” ascribed to Bilvamaṅgala, are still unpublished; on whose examination, it has been found that there are several verses common to the southern recension of “*Kṛṣṇa kaṇāmṛta*,” known to its commentator Pāpayallaya Sūri who wrote his commentary “*Suvarṇaśaṅkā*,” early in the 15th century in three parts called “*ullāsa*” or “*āśvāsa*” making in all about more than 300 verses. Other commentaries on K.K. following an earlier tradition accept the text as containing more

¹¹ For a detailed history of Bilvamaṅgala Līlā Śuka, the reader is referred to an article by Naṭvarlāl I. Desāi, B.A., in “The Gujarātī Weekly” for November 1934, Diwālī Number.

¹² Edited by the late A.B. Jāni, B.A., and published by the Forbes Gujarātī Sabhā, Bombay, in 1933.

than one "āśvāsa" (canto). Some of these verses are also common to the new work so far known to us as the "*Bālagopāla Stuti*", six sets of which with beautiful miniatures in the style of western Indian Painting have come down to us, though in fragments. A publication of the text and the miniatures of different periods during 1400 A. D. to 1600 A. D. of this work of Sanskr̥ta verses of devotion to Bālakṛṣṇa is desirable.

The discovery of the "first of the series" of the *Bāla-gopāla-stuti* miniatures in 1929, established the existence of a school of miniature painting prevalent in western India, especially Gujarāt and Rajputānā, without reference to any creed. The great attention it drew of scholars can be seen from references made to it by them.¹⁸

Three of the miniatures (without text) from this fragmentary series were reproduced in black and white in Vol. IV. No. 2 of *Indian Arts and Letters* and one folio was reproduced in colour by Prof. Brown in his "Story of Kālaka". One typical illustration is copied here (*Plate V*) with a view to help us in comparing the details of technique and the style of delineating dress, ornaments, trees, cows, etc., with those which are being published here.

The leaves of this Mss. are $9\frac{1}{2}" \times 4\frac{1}{2}"$, each page bearing a miniature illustration, $5\frac{1}{4}" \times 4\frac{1}{8}"$, placed on the right side, with the Sanskr̥ta text of the hymns, about nine to ten lines, on the left side. On the reverse also are texts of hymns written between two rubricated perpendicular lines without any miniature.

During the later part of the 14th century A. D. and the early part of the 15th century, at the end of the "palm-leaf period" and the beginning of the "paper," Gujarati miniature paintings have a special delicacy and refinement unknown either in the earlier or even later examples, and yet without the profuse embellishment and frequent degeneration of the late 15th and 16th centuries. The best miniature paintings of the early western Indian school seem to have been executed shortly before and after 1400 A. D. roughly from about 1350 to 1450, at the time when paper was supplanting palm-leaf as the surface for writing in Gujarāt. The illustrated Mss. of whatever quality, which can be assigned definite dates during those 100 years are comparatively few : but those few with



14. Child Study



15. Child Study



16. Child Study

¹⁸ See the *Addenda* to the critical edition of *Lilā Śuka Bilvamaṅgala's Kṛṣṇa-karṇāmṛta* with three commentaries, by Dr. Susila Kumār De, pp. 371-372 (Dacca, 1938).



17. Hair-dressing



18. Hair-dressing

other dated illustrated Mss. from before and after that span, provide fixed points between which other undated material can on stylistic grounds be arranged so as to show the existence and development of several variant styles side by side.¹⁴ As time went on, with the growing use of paper, the size of the folios was enlarged, and the available surface for the paintings was correspondingly increased. The form of the miniatures also changed; for paper not only offered a larger area for the painting, but also provided a surface susceptible to finer workmanship. The broad, simple lines of the earlier miniatures gave place to a more delicate, if often weaker, drawing and to an elaboration of the composition with minor elements and a multiplication of detail. The miniatures of the paper period, as compared to the palm-leaf period, are accordingly more elegant, more sophisticated, and more decorative.

A great change took place also in the colour scheme. Gold came to be employed instead of yellow (cf. "third series" where gold is shown on the circular ear-rings). In the subject-matter of the miniatures, also, there came about a change. The few narrative scenes of old, increased to a heavy preponderance of narrative scenes. But, with the growing demand for paper Mss, the multiplication of copies became easier, and the quality of the miniatures suffered. The scenes depicted became stereotyped. Each artist seems to have reproduced those known to his predecessors, and the depicting of new scenes was comparatively rare, although as time went on, more and more were introduced, and the late Mss. contain sometimes twice as many scenes as the early paper manuscripts. The compositions were also standardised and they appear with only slight individual variations in different Mss.

The "second illustrated series" (size of the folio 9" x 4½") of the "Bāla Gopāla Stuti" runs to 65 folia (with a gap of 8 folia, the last folio being marked 65) with the text of verses going beyond 350 in number; but it has no colophon: This series, since acquired by the Baroda Museum¹⁵ was remarked by me in 1933 when the Mss. was exhibited before the 7th session of the All India Oriental Conference, Fine Arts Section, and a bare account of it was published in the Proceedings, without any illustrations (see Plates VI, VII, VIII).

¹⁴ Vide: "Stylistic varieties of Early Western Indian Miniature Painting About 1400 A. D.," by Prof. W. N. Brown, J. I. S. O. A., 1937.

¹⁵ All illustrations from the Second Series are reproduced through the courtesy of Dr. H. Goetz, Curator, Baroda Museum and Art Gallery.

The fineness of the outline and the technical skill displayed in these miniatures surpass the miniatures of the "Vasanta-Vilāsa" scroll, and they have very much in common with the "first series" of the "Bāla gopāla stuti." It may be, that this and the other set of miniatures might have been painted by the self-same artists or they may be copies from an equally fine original prepared in the enthusiasm that spread in the train of the use of paper, which supplanted palm-leaf. (See illustration. Plate III. Govardhanadharāṇa.)

A very vigorous sketch of four-armed Viṣṇu as in the "*Bālakṛṣṇa-kṛīḍā-kāvya*" folio is met with in the "*Devīmāhātmya*" Mss. where he is shown to have killed Madhu and Kaitabha. In this miniature, (Plate XVII) two hands of Viṣṇu are shown in momentous action and the heads of the demons, severed from the body are seen on either side of his lap. At the left hand top corner is shown the conventional sky or the clouds, which motif was later on adopted by the Rājput painters. The facial appearance, the drapery, ornaments etc. of Viṣṇu and the two demons are in the conventional Gujarāṭi type of painting.

The "third series" (size of the folio 9" x 4½") represents a sub-variety of the paper-period style of miniature-drawing. There are attempts at shading by thicker lines in the human faces, dress, architectural settings and even decorative designs. Though full of vigour, a crudeness clings to these renderings of the poet's ideas in line and colour. As contrasted with this series, the previous two series, display a higher quality, a more elaborate drawing, finer and more details. In the first two series referred to above, the composition of the paintings are worked out with the most elaborate care and profusion of detail. Personal ornaments and architectural settings are minutely finished, and the fine lines might have been done with a "single-hair" brush.

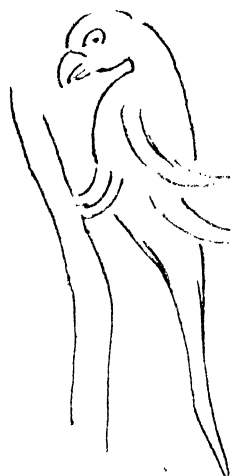
In the less elaborate series of the "Bāla-gopāla stuti" the costume designs though rich, the elaborate weaving and embroidery of the textiles and the intricacies of the jewellery and also the foliage of trees, are suggested rather than indicated with precision. The lines consist of very



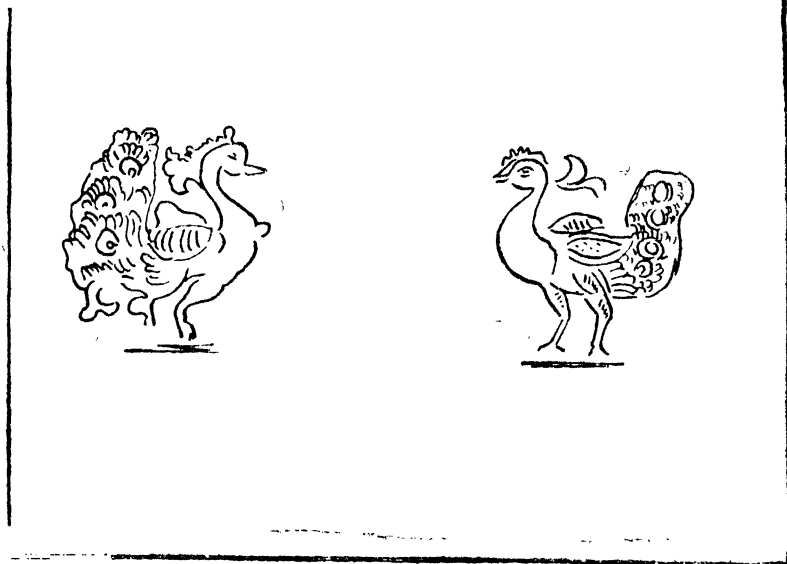
19. Hair-dressing



20. Birds



21. Birds



22 Birds

few and sometimes very thick, strokes. They have no flux and are joined angularly at times. The eyes are not drawn as a pair on a continual horizontal axis, as is generally the case in the finer variety; but are drawn on separate axes at different levels, so that the inside corner of one eye is considerably below the level of the other (see Plates IX, X, XI, XII).

The "fourth series," which is in a very bad condition and only 11 stray folia of which have been rescued (size of the folio 9" x 4") is still very valuable as it helps us to establish the continuity of art-tradition in western India, where the same technique in painting with a few local variations prevailed. From the fact that a tendency towards the profile of the face showing only one eye is evident, it may be assigned to a slightly later date than the two sets referred to above, as the delineation of poses has become stiff and stereotyped lacking in the telling effect of the outline. However, it cannot be later than late 15th or early 16th century as is evident from the brick-red background and vestigial red dots in the margin.

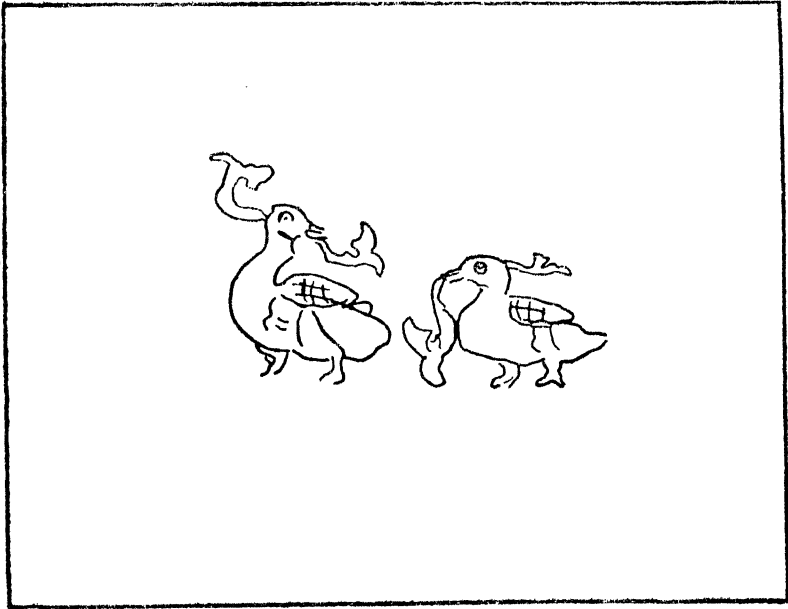
The "fifth series" (size of the folio 11" x 5") though obtained in 29 folia only, with an equal number of miniatures is very valuable, as the same theme has been worked out in a little different and a derivative style known as the "Early Southern Rājasthāni." This Ms. supplies information as to the probable extent of this "stotra-like" work; the extant 65th folio of the manuscript stops short after verse 352, and yet the colophon is missing. It is therefore desirable that a comparison of the verses copied in the various illustrated Mss. be instituted with similar reputed works of Bilvamangala such as the "Bālakṛṣṇa stuti", "Bālakṛṣṇa Kṛiḍā-Kāvya" and the "Kṛṣṇa-bāla carita" in order to collect data to

enable us to find out the right name of this loosely connected "stotra"-like work, wherein the colophon-like name of "Bālagopāla stuti" occurs after verse 108 only. The affinity of these texts with that of the "Kṛṣṇa Karmāmṛta" is also worth a study.

The elegance in the delineation of faces, in clear profile with a long eye, the costume which for the first time shows the skirts worn by the ladies, the long series of bangles with pompoms and such other details, lend a special charm to these miniatures; and yet the artist has not thrown off his allegiance to older motifs and a simple colour-scheme which he has repeated in his version of the old Vaiṣṇava theme. (Plate XIII).

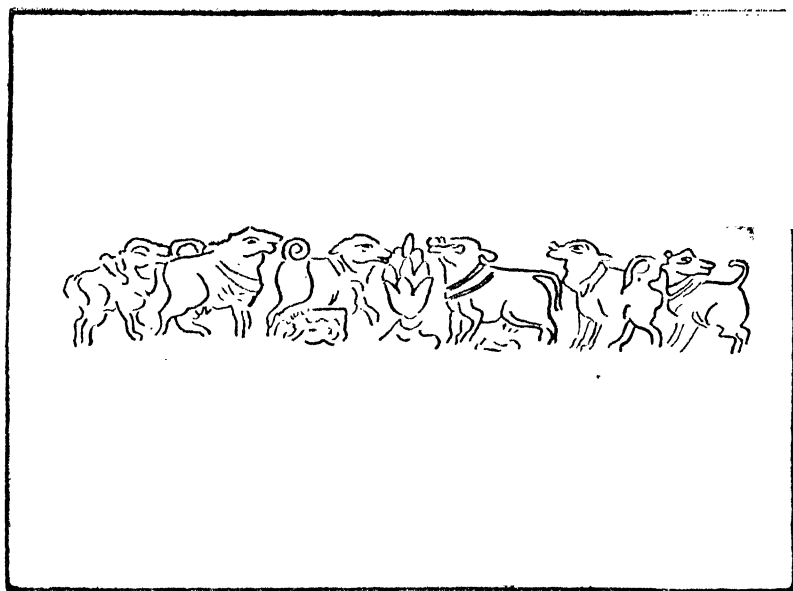
It has been possible to give illustrations from three series, of the same verse (Plates XIV, XV, XVI) which describes the rambles of Kṛṣṇa with his companions and cows in the shady forest of Vṛndāvana (maṇḍam maṇḍam nudati pavanam etc.)¹⁶ to show by juxtaposition the effect of rendering the self-same verse at the hands of different painters at different periods. The treatment of trees, the conventional sky-line, the sketches of the cow and the poses of "gopas" with the hockey-stick are characteristic.

The style of the miniature and the calligraphy, which invariably makes use of "prṣṭhamātrā," in these Mss. (being reduced to the minimum in the "Fifth series") and the presence of simple, vestigial red dots on either side of the margin (disappearing completely during the Rājasthāni



23. Birds

¹⁶ "मंदमंदं नुदति पवनं वेणुमापूरयंतं । वृंदं वृंदावनभुवि गवां चारयंतं चरंतं । छंदोभागे क्षतमखमुखध्वंसिनां दानवानां । हंतारं तं कथय रसना गोपकन्याकिशोरं ॥"



24. Animals

period) mark the transition from palm-leaf to paper; they help in assigning the probable date of these Mss. It is impossible, however, to arrive at their exact date, one and all being incomplete; but, from the appearance of the size of the page itself which borders on 9" x 4½" on an average (the size of the folio of the fifth series being 11" x 5"), the handwriting which is not as large as in typical 16th century or late 15th century Mss. (viz. the Fifth series), the use of brick-red in the backgrounds of the paintings without blue, these Mss. can be assigned roughly to the 15th century. The "Fifth Series" serves as a connecting link between the Gujarāti and the Early Rājasthāni styles of miniature painting.

From the point of view by which the sartorial evolution helps in fixing the dates of Indian miniatures, these illustrated Mss. of the Gujarāti school of painting are specially interesting. Printed textiles with variegated designs mostly produced in western India were in vogue, like those unearthed at Fostat, in Egypt.¹⁷ The costumes depicted in painting have reference only to Gujarāt of the 12th to the 15th centuries; and, they must, therefore, be regarded as typical only of Western India. Men wore a "dhoti" reaching up to the ankles with a short scarf thrown across the shoulders, leaving the upper half of the body uncovered. This dress appears to have been the typical Hindu male attire for at least the past 2000 years. There have been only minor variations in the male outfit during all these centuries.

The headgear usually employed is a kind of peaked cap or "mukuta" which degenerated later into the hideous cap of the present day. The

¹⁷ See plates in 'Les Toiles Imprimées De Fostat Et L'Hindostan' by F. Pfister (Paris, 1938).

turban, seen in Rājasthāni miniatures prior to or just contemporary with the Mughal period, is a debased form of the then prevalent headgear, probably adopted later with some variation by the Mughal courtiers.

It will be noticed that the male costume differs but little from that in vogue during the period of the Ajañtā paintings. Important figures (such as Avalokiteśvara, Cave I Ajañtā) wore a "mukūṭa," the *dhōṭī* reached to the knees, and the body above the waist was bare. Men wear the waist-cloth ("dhōṭī") long or short, and a scarf for the shoulders. The 'mukūṭa' only has changed becoming less elaborate, till it became a mere travesty of a dignified headgear later on.

While the male costume appears to have remained the same for centuries, feminine draperies have been subject to radical changes of fashion. The "sārī" typical of modern Gujarāt, was not known to the artists of these Pre-Mughal miniatures. The women wore a long, gaily coloured scarf, broadest at the ends, coming down from the shoulders and hanging loose below the knees. The lower portion of the body was wrapped in a different coloured "dhōṭī".

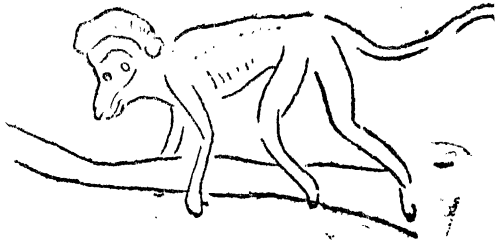
The skirt, excepting in the "fifth series," seems to have been unknown but it is found in early Rājasthāni examples; its place in later examples, is taken by tight drawers (under Muslim influence) coming to the knees, and sometimes a little beyond. A tight fitting bodice or "choli", covering the bust almost down to the waist a little above the navel, and covering the arms upto the elbows, was in vogue.

The "*pyjāmā*" appears to have been totally unknown as also the turban which came into fashion with the advent of the Mughals half a century later, and was adopted by Indian aristocracy, Hindu and Musalmān, as part of the national costume at least in the courts of Northern India and Rājasthāna.

The drawing of Gujarātī painting is entirely linear; accordingly the pictorial aspect of some of the prominent art-motifs if illustrated by a number of "outline sketches"¹⁸ would afford a vivid idea of the lively

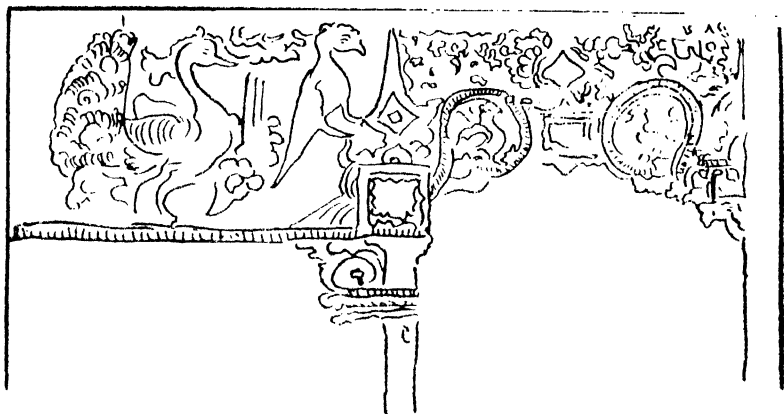


25. Animals



26. Animals

¹⁸ Vide the thirty sketches copied from these Mss. in original size and reproduced here.



27. Architectural Settings.

movements and gestures of the figures, of the treatment of trees in schematic silhouette with each leaf separately represented and the rendering of landscape and clouds, dress, ornaments, furniture and other accessories (Vide Colour plates). These things make the miniatures interesting both from aesthetic as well as the sociological point of view.

The paintings in the Gujarāti miniatures can be singled out from those of other kindred schools through certain pictorial art-motifs : such as the occasional purely decorative use of flowers to fill the empty spaces, the fondness for clouds, the conventions for the treatment of natural elements such as water, fire, rocks, the costumes with printed designs, the raised wooden seats and the symmetrical delineation of trees bent to suit the composition : These are points remarkable at first sight in the Gujarāti and the Early Rājasthāni miniatures.

The artist uses the line to seize the essence of human and animal forms and loves to render them in many attitudes and positions. The human figures are not individualistic but rendered to certain formal types. In spite of the stereotypisation of human forms the Gujarāti artist makes up for such deficiencies by rhythm where every limb is depicted to show action and vigour. Trees, water, clouds, houses also partake of some of the formalism that helps to simplify the content of the picture. The forms are no imitations of nature, their naturalism is more apparent than real, just as persons of lesser importance are cast in a slightly smaller mould.

The art-motifs evolved by the Gujarāti painters especially in the treatment of natural elements is remarkable. Water is indicated (in an ocean or river or lake) by wavy lines crossing at various angles with or without aquatic animals like the fish and the tortoise. A typical motif in Gujarāti, Rājasthāni and Rājput art is the water with or without lotus foreground which constantly reappears in the Nāthadwārā Series.

Rocks, hills and mountains are painted as stumpy elevations sharply defined by accumulation of jagged-peaks, with trees, shrubs and even wild animals. The uneven earth is shown with green verdure.

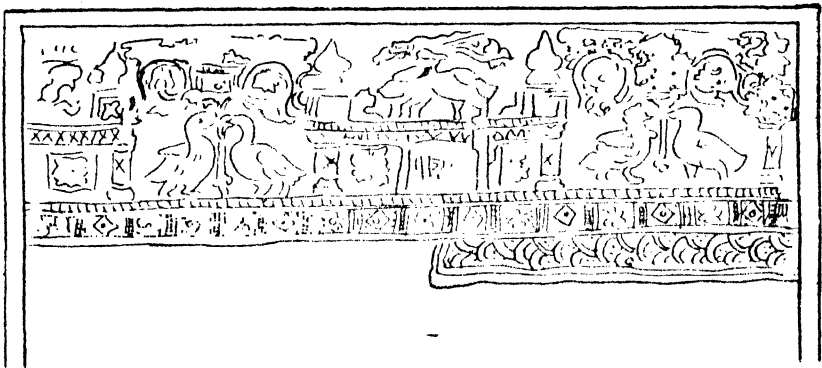
The clouds in the Gujarāṭi painting remain straight or wavy lines, a shape in which they appear in some subjects. The narrow strip of sky filled with ragged cloud is characteristic of Gujarāṭi and Rājasthāni works alike, and may be regarded as archaic. The manner of rendering the hanging clouds on the horizon in the later Rāgiṇi pictures are derived from the models of clouds depicted in these Gujarāṭi miniatures of the 15th century. In landscape subjects, the horizon sometimes reaches nearly to the top of the page, leaving only a narrow strip of sky in which are depicted heavy storm-clouds. The flowing streams and the hovering clouds add to the beauty of the background.

The foliage of trees in these pictures has been treated as a silhouette. Plants are shown in a conventional manner especially the plantain, the mango, the stately palm, the "molsiri" and the beautiful pomegranate.

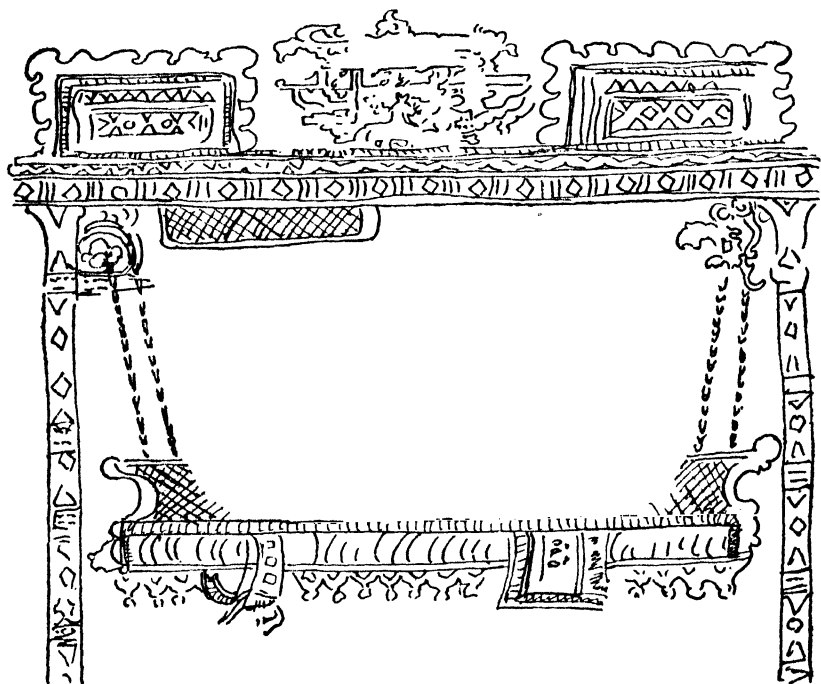
The main furniture in an ancient Indian house consisted of a few bed-steads and raised seats. The swing, which is characteristic of Gujarāṭi homes, hangs from the twigs of the tree in Picture No. 64 of the "Vasanta-Vilāsa": its artistic richly dressed type in home is met with in the "Second Series" of the Bāla-Gopāla Stuti Mss. where Kṛṣṇa lies at ease. (Vide the outline sketch). The swing appears in Ajantā frescoes hanging from a wooden frame (Cave II, Ajanta : Irandati : Vidhur Paṇḍit Jātaka).

The other kind of homely furniture illustrated several times in the Gujarāṭi miniatures include the triple hangings called "torāṇas," curtains ("Candaravā"), the fly-whisk, a small hearth and water-jugs. The popular motif of a water-vase (maṅgala-kalaśa) with the two conventional eyes, perhaps signifying omniscience, is commonly met with in both Jaina and non-Jaina manuscripts.

The most conspicuous peculiarity in the delineation of the human form, is the three-quarter profile position in which nose projects beyond the outline of the cheek, and the corners of the eyes are extended. The round and oval shaped nimbus around the head of persons is a conventional motif, which suggests nothing special about it, as it is not limited to divinities and important persons alone.



28. Architectural Settings



29. Furniture : A Swing

As a common feature of the toilet of the men and women of mediæval Gujarāt, the motif of star-shaped circular earrings is so prominently remarkable, both for its shape as well as size. The "mukuta" is a common feature both with men and women, usually of high position.

The "sāri" covering the head of ladies is unknown in the pre-Mughal paintings of pure Gujarāṭi styles ; the ladies are accordingly seen with their hair loose, wearing them into a single braid ("veṇī") hanging down beyond the waist, ending in a black tassel, which may be noticed behind. Modern Gujarāṭi ladies are resorting to this style of a single "veṇī" hanging loose behind with a silken tassel at its end. Necklace and the "veṇī" mark out the feminine figures with a delicate grace. The long and black tuft of hair hanging down beyond the waist are visible because the "sāri" prior to the Mughal rule in Western India never used to cover the head as it did in later Rājput and Mughal miniatures, influenced by foreign rules of etiquette.

The beard is generally associated with the conception of a male figure : the U-shaped mark on the forehead is indiscriminately used without any reference to religion.

The world of these miniatures is peopled with an abundant animal and bird life. The artist uses the line to seize the essence of their forms and loves to render them in many attitudes and positions but above all he is interested in showing their kinship to man.

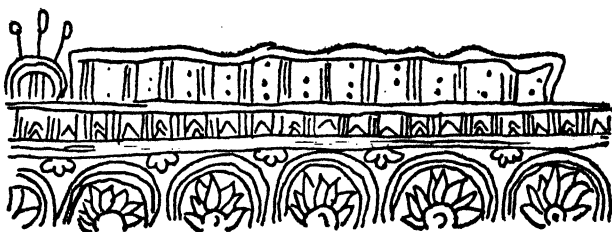
Among animals and bird-life that are depicted, cows, monkeys, deer, fish, peacocks, parrots, squirrels, the crow and the cuckoo are most frequently painted. Cows, the popular accompaniment of cowherd Kṛṣṇa, are especially drawn with vigorous movements of limbs.

Things change but slowly in this country, and it is surprising to see from these miniatures what little change there has been in furniture fashions and household wares during the space of well-nigh four centuries ! Medieval gentry in Gujarāt appears to have been peculiarly fond of richly coloured, generally blue and red bed-spreads, covering large commodious beds.

The characteristic and universal features of Gujarāti households and the detailed view of life and habits of the people in western India in the 15th century can be seen from the furniture illustrated in these Mss. such as the "torāṇas," curtains, swings, wooden bed-steads, musical instruments, the fly-whisk, the mirror and water-jugs.

The outstanding features of these miniatures are among other the brick-red background, the simple colour scheme, round yet angular faces, eyes drawn out to the ears, further eye protruding beyond the facial line, eye-brows in simple curves, pointed nose, the large circular earrings, the floral decorations and a general indifference to elegance, at times stressing the pointed directness.

The cumulative weight of these illustrated Mss. of a non-Jaina theme strengthens the existence of a common art-tradition in Western India, especially in Gujarāt, Rajputānā and Western Mālwa. The three main sources of Vaiṣṇava devotion and philosophy—the "Bhāgavata," the "Gītagovinda" and the "Bālagopāla stuti" were illustrated in the local style of Western Indian miniatures by the painters for their patrons of the wealthy middle class.¹⁹

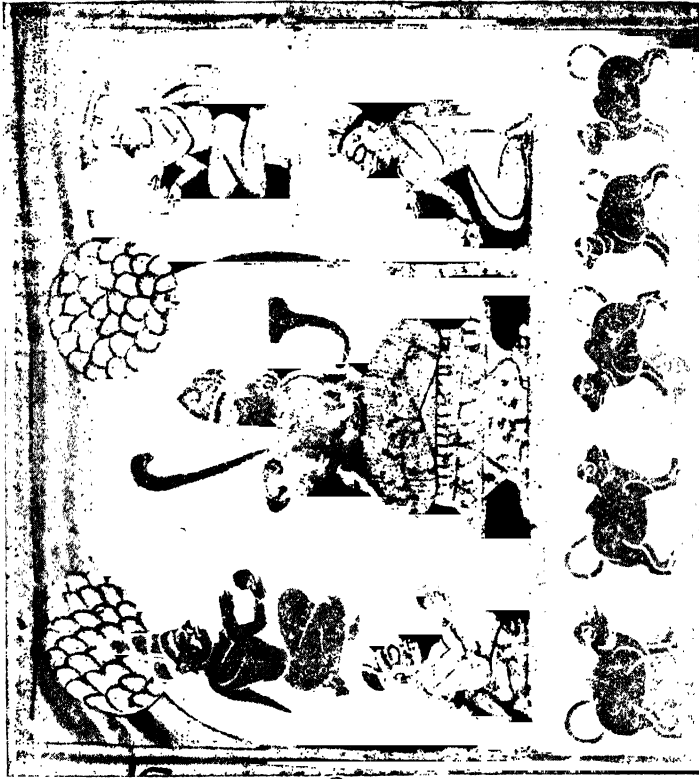


30. Furniture: A Torāṇa

¹⁹ This paper is published as a result of researches carried on as the Springer Research Scholar of the Bombay University.



Kṛṣṇa in the midst of cows and Gopīs in Vṛndāvana (From First Series in Boston Museum)



बिभ्रद्रेणुं जठरपटयोः शृंगवेत्रे च वक्षे ।
 वामे पाणी ममृणकवलं तत्फलान्यंगुलीषु ॥
 तिष्ठन्मध्ये स्वपरिसुहृदो हासयन्त्रमभिः स्तैः ।
 स्वर्गे लोके मिषति बुभुजे यद्भुगबालकैलिः ॥
 भागवत । दशमस्कन्ध । १३-१२

Feasting of Gopas : From Bālagopāla Stuti Mss. Fourth Series illustrating Bhāgavata X, 13-11



वृषावकारगोपेयश्च प्रस्योप
 रिशोनिशिगीवर्धनहृत्तन्म
 र्द्वर्धनीवृषागोपराट्॥दृष्ट्वा
 स्वायिरीशोचरतोसमर्थोनी॥
 नोपिपुंभतमसप्रदीय॥वरी॥
 एधारातयनातवद्विरोरिएस
 नीरहराकृतम्॥दृष्ट्वा श्री॥



Exquisite Mirror Design—From the Series
 from the Museum of Art, University of California, Berkeley, Mo.

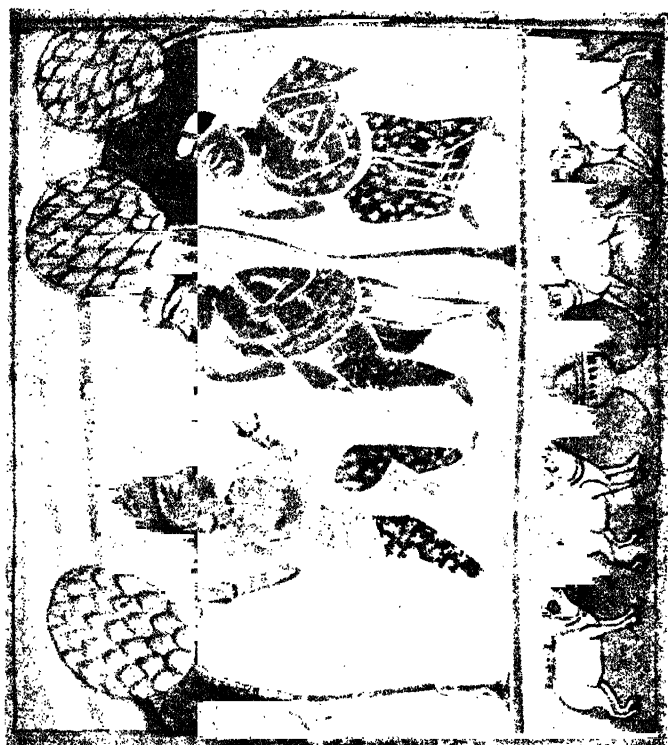


Vandae carvée new born, Beldice, 1910—From the Series



नारायणायनमदत्तयमेवमत्पसंसार
धारविषमंदरणायमन्त्रः। अष्टपुंड्रसर्वस्व
योगोदितान्तरागान्त्रिंशत्तुष्टिनाम्
रुद्रद्विजा॥ एतन्निश्वरमहंस्वबाहक
मायाद्विस्वमंगलधरविनाश्रीबालगो
पान्तुतिः॥ इति माध्वपुराणेनगवक्षक्य
॥ १५० ॥ ॥ ॥

Folio 21 from *Bhagavad Gita*, Second Series, Catalogue of Ganga, Dr. Pitt and the Author of the Work



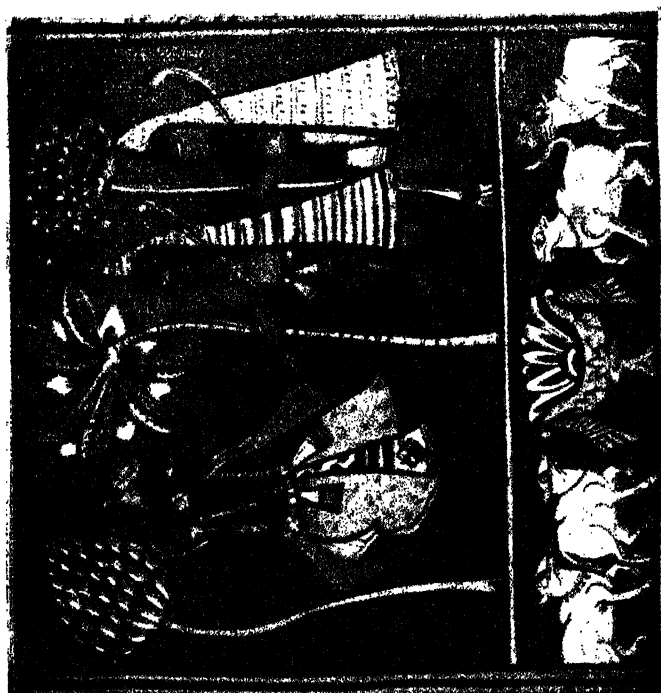
Kirtimukha Gopas in Vinadhama From Fourth Series



Kirtimukha Gopas in Vinadhama From Fourth Series



Vishnu killing Madhu and Kaitabha by keeping them on
 a lotus while in undecan. From MS. of Desh
 Mohaveva in the Baroda Museum Art Gallery



Krishna with Gopas in Vrindavana. From Fifth Series

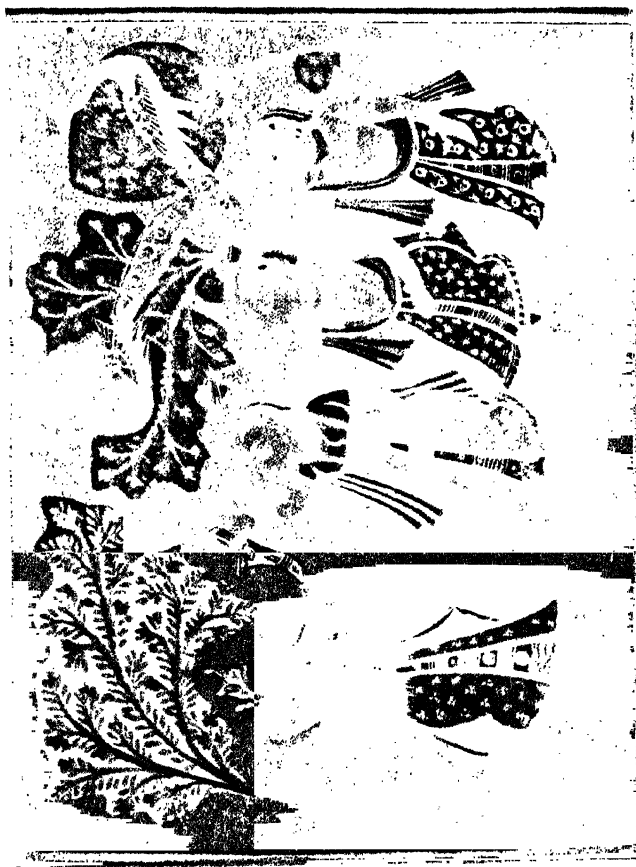
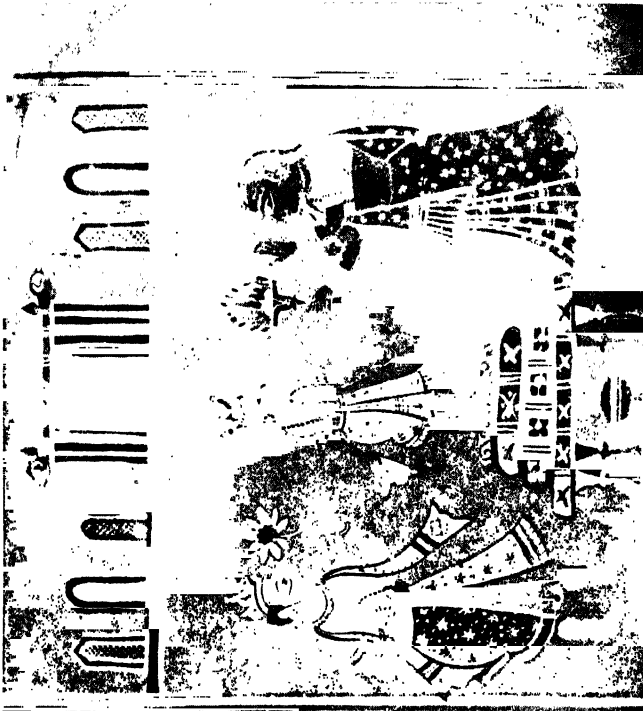


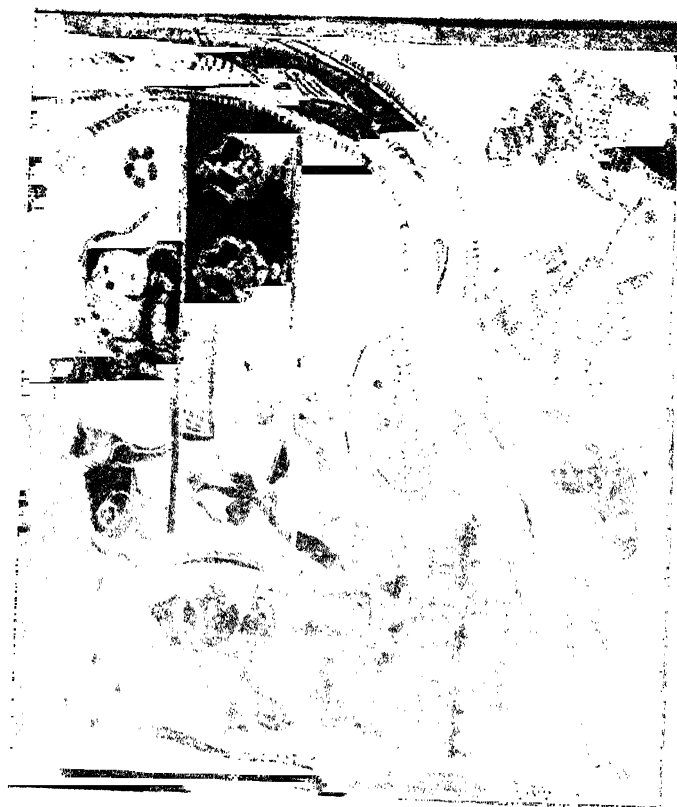
Figure 1. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains. The *Agrobacterium* strains were incubated in the presence of 100 mg/ml of gentamicin and 100 mg/ml of rifampicin. The concentration of the *Agrobacterium* suspension was 10⁶ cells/ml. The transformation efficiency was determined by the number of transformants per 10⁶ cells. The data are the mean ± SD of three independent experiments.



सन्नेनाद्यगतेनरंभधुनाष्टद्वितास्वेच्छयसर्ग्यं
 विमितदादमुशलीमिषांवपणनं व्यादेहीतिशि
 काशितेवदनेदृष्टासमस्तंजगत् मातातस्यजगत्
 विस्मयपटपायाञ्चवःकेशवः २७६ कस्मैचिन्मा
 हसेमनःप्रसुवताचंदशिषामंडली नापिप्रसवार्त
 मरुचयेवाचलातोलयःनिव्याजस्मयमाननासरा
 सीमालीकंगोलसवलतक्षलीयकपुनःपुनपरिणा
 मत्कल्याणमस्तु ७ए कल्याणमस्तु ७

Plate I illustrates. Adbhutarasa : Kṛṣṇa showing three words to Yaśodā by opening the mirth Verse 278)

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Known as the 'Vase of the World', this object is a famous work of art.







Lifting of Govardhata



Govji welcomes Krishna with his comrades

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THE PROBLEM OF KARṆABHĀRA*

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KARṆABHĀRA is the shortest of the epic plays written by Bhāsa. It contains matter which does not run for more than ten printed pages of a book. It is a very beautiful piece. It will be presumptuous on my part to imagine that the beauty of the play has not been recognised by scholars who have studied it. I do feel, nevertheless, that a proper and a correct aesthetic approach is what is necessary in the study of a work of art. Such an approach naturally yields the inevitable judgement of value. And what is more important, it sometimes helps to solve problems that refuse themselves to be treated by the so-called scientific method of a cold scholar.

There are altogether three questions connected with Karṇabhāra :

- (1) What is the correct interpretation of the title ?
- (2) Does the play end abruptly? or is it complete in itself?
- (3) Is it a tragedy?

The questions are obviously inter-connected. And so are their answers interlinked. I propose to answer them by subjecting the play to an internal analysis.

Gaṇapati Śāstri, Woolner and Sarup take the title of the play to mean "Karṇa's task or responsibility" referring to the generalship of Karṇa in the great Kuru war.

Gaṇapati Śāstri thinks that at least one more act is necessary to describe the feats of Karṇa. Woolner discusses the outline of the original story as it occurs in the Mahābhārata and says: "Our dramatist simplifies the story. Karṇa sets out with Śalya for the fight with Arjuna. Three times he tells Śalya to drive his car where Arjuna is, and the play ends abruptly on that command."¹

Pusalkar who holds the opposite opinion, thinks that the play is complete in itself and explains the title as :

कर्णयोः भारभूतानि कुण्डलानि दत्त्वा कर्णेनापूर्वा दानश्रुता प्रकटीकृता ।
तामधिकृत्य कृतं नाटकम् ।

Karṇa felt the Kuṇḍala as a burden (Bhāra) to his ears (Karṇa) once they were verbally declared as a gift and so long as they were not taken away. Karṇa thus appears in the most favourable light in his selfless generosity and magnanimity. This is the object of the play, says Pusalkar; and as it is fulfilled, the play is complete in itself.. "It

* Paper written for the All India Oriental Conference, Nagpur, 1946.

¹ *Trivandrum Plays*, Woolner and Sarup, Volume II, p. 32.

does not mean Karna's task and therefore, there is no necessity of describing Karna's deeds or showing his death . . . 'The burden of (Karna's) ears' is the only correct interpretation... Bhāsa has shown similar subtlety of meaning in naming one of his plays as *Pratimā* . . ."

The alternative title "*Kavachāṅka Nāṭaka*" supplied by another Mss. supports, according to Pusalkar, his interpretation of the title. The word "*Āṅka*" very probably means "*Utsṛṣṭikāṅka*," though of course, "*Bhāsa's* works do not conform in every minute detail to the definitions given in our extant texts on dramaturgy". This data signifies that the play is a one-Act and complete in itself.¹

Though Pusalkar's view about the play being a one-Act is correct, I am not quite sure of his interpretation of the title and of the subject of the play that he has deduced or assumed. To say that "The play was written for didactic purpose, possibly to impress on the minds of the princes the importance of generosity"² is clearly to misunderstand or ignore the supreme object of literary writing. It is true that works are written for didactic purposes; but not works which are professedly literary. Whatever "*Upadeśa*" there is in such works is imparted always in a suggestive and almost imperceptible way, in the manner of a loving wife, as Mammata would say. "*Sadyaḥ paranirvṛti*" or sheer aesthetic joy remains always the primary aim of literature. It will, therefore, be necessary to change the entire standpoint and collect the essential data from the material that Bhāsa himself has furnished us.

The whole problem is obviously connected with the theme that Bhāsa has chosen for this play and the dramatic treatment he has given to it.

The story of Karna is related in two different parts of the *Mahābhārata*: (1) MBh., Bk. 3, sections 300-310, which are called "*Kuṇḍala-haraṇa-parvan*" describe Śūrya's warning to Karna in a dream against the trickery of Indra. Karna refuses to profit by the warning. Śūrya then begs him to demand a magic lance in return for the gifts of the *Kavacha* and *Kuṇḍala*. Karna accepts to do so. It was this very lance which Karna further used to kill Ghatotkaca. (2) MBh. Bk., 7, which is called "*Karna-parvan*" describes the end of Karna. Karna takes over the chief command of the Kuru army and undertakes to fight Arjuna. But Śalya, his charioteer, is extremely unsympathetic. By using his gab freely, by pointing out evil omens, and by picking up a quarrel, Śalya does his best to dishearten Karna. Karna fights nevertheless. He kills five of the *Pāṇchālas*, disarms and humiliates Yudhiṣṭhira, till he is engaged in a duel with Arjuna who finally shoots his head off.³

This original story Bhāsa has not only "simplified" but subjected to a striking transformation.

The actual changes are as follows :—

- (1) The incident of Indra receiving the armour from Karna occurs earlier in the original story, when the *Pāṇḍavas* were in forest and not on the battle-field as Bhāsa has depicted.

² See Pusalkar, *Bhāsa—A Study* : pp. 188-191.

³ *Ibid.*, p. 191.

⁴ See *Trivandrum Plays*, Woolner and Sarup, p. 31, Intr.

- (2) The epic story mentions Sūrya appearing in Karna's dream and giving him a warning against Indra's trick. Bhāsa omits the dream.
- (3) According to the original, Karna demands the magic lance from Indra at the bidding of Sūrya. Bhāsa's Karna does nothing of the kind.
- (4) Bhāsa's Śalya too presents altogether a different picture. He does not abuse, dishearten or quarrel with Karna. He is nothing if not completely sympathetic to Karna.
- (5) The appearance of Indra in the guise of a Brāhmaṇa is supported by the epic. But the idea of making him talk in Prakrit, and talk in the way he does, is Bhāsa's own.

Besides, Bhāsa has added a few details that are altogether original and of his own invention :—

1. Karna enters on the very opening of the play with a mind terribly oppressed with gloom. And this mood never changes till the play ends.
2. Karna narrates the tale of Paraśurāma's curse.
3. After the gift of Kavaca-Kuṇḍala, Bhāsa makes Indra send a Deva-Dūta who bestows a missile on Karna.

Now, what is the significance of these changes and innovations? What is their value for dramatic construction and design? And what light do they shed on the purposes and motive of Bhāsa's composition?

Bearing in mind the two separate parts where the story of Karna occurs in the epic and looking to Bhāsa's dramatisation, it becomes at once clear that Bhāsa has based this play mainly on the Kuṇḍala-haraṇa theme. The actual fights that Karna wages and his final duel with Arjuna in which he loses his head are not at all countenanced by Bhāsa. The play opens on the scene of battle ground. Karna is already in his car and ready to fight. He is asking his charioteer, Śalya, to be driven to the place where Arjuna is. As the chariot is apparently wending its way, Karna is thrown into a depressing gloom. He becomes reminiscent and narrates the story of the curse hanging on his missiles. But he braces himself up and proceeds to his destination. Just then he is interrupted by a Brāhmaṇa who demands the gift of Kavaca-Kuṇḍala from him. This episode occupies the better part of the play. And as Karna satisfies the Brāhmaṇa and once more gives the order to be driven forward, the curtain comes down. This is the picture that Bhāsa has painted. If we carefully remember this, two important results seem to follow immediately :—

(A) In the first place, it is obvious that Bhāsa is not interested in depicting the whole life of Karna with all its material events and incidents. He is rather concerned with the single idea of focussing the personality of Karna on the stage. For this purpose he has selected certain relevant details in Karna's life which he weaves in the theme with varying technique. Bhāsa concentrates mainly on a psychological picture of Karna. The Kuṇḍala-haraṇa episode provides, Bhāsa thinks, the keynote to Karna's character. It is, therefore, openly and elaborately dramatised. The ominous curse on Karna's missiles is introduced by a gloomy, reminiscent narration. And the end of Karna's life at

the hands of Arjuna, is clearly foreshadowed by mighty unmistakable suggestions. Thus, for the purpose of this playlet, Bhāsa has fused the Kuṇḍala-haraṇa parvan and the Karna-parvan together. Or rather, it will be more correct to say that Bhāsa has taken away the Kuṇḍala-haraṇa episode from its original background and transplanted it on the background of the Karna-parvan with its tragic implications of fights and death. This at once projects to a sharp point Karna's flair for selfless generosity—the central trait of Karna's character, and a tragic trait also as I will shortly show. And the dense scene of the battle-field provides the striking and tragic background to this picture making it all the more touching. This, indeed, is the theme of Karna-bhāra.

(B) Secondly it is this theme that gives the play its unity making it a self-sufficient piece. The failure to realise this point has misled all critics. Those who have looked into this play for the dramatisation of the epic story and for the physical incidental details of Karna's life have really looked in vain. This is true of all the short plays based on the Mahābhārata. Those who have read them will know that it is never Bhāsa's habit to turn the original story into a tame dialogue-pattern. Nor is he satisfied with accepting the general structure and introducing a few occasional changes. He freely invents and sometimes as in the case of Dūta-Ghaṭotkaca, invents the entire material for a short play. Bhāsa's general method is to pick up a single episode from the epic story and turn it into a piece that has its unity and completeness. All the Mahābhārata plays bear an aspect at once different from the two Rāmāyaṇa plays. Bhāsa's selection of a theme and its treatment, therefore, leave no doubt as to the nature of these short plays. They are complete.

The transplanting of the Kuṇḍala-haraṇa episode on the battle-ground besides lending the play its structural unity serves a dramatic purpose as well. As it comes here it helps to focus the central idea of impending doom that awaits Karna. To realise this the characterisation of Bhāsa must be properly understood.

Bhāsa's Karna is utterly selfless. He does not ask for any return gift from Indra. And when Indra sends his Angel to present the gift of an invincible missile Karna straightway refuses to accept it. He is finally forced to take it simply because the words of a Brāhmaṇa cannot be transgressed⁵. Bhāsa's picture therefore is of a personality that is far nobler in its limitless magnanimity of heart. Winterneitz thinks that, "The Karna of Mahābhārata is a far more interesting figure than that of our one-Act play."⁶ I do not know how. But I do feel that Woolner is right when he says that, "This Karna is throughout more saintly than the epic Karna".¹ This change that Bhāsa has made in the conception of Karna's character is very important. Karna impresses us to a degree. The feeling of sympathy for him is unalloyed and complete. And unquestionable sympathy is, indeed, the prerequisite in the making of a character that is meant to move us to the

⁵ Read : कर्णः—भिग् दत्तस्य न प्रतिगृह्णामि ।

देवदत्तः—ननु ब्राह्मणवचनाद् गृह्णताम् ।

कर्णः—ब्राह्मणवचनमिति । न मयातिक्रान्तपूर्वम् ।

⁶ Winterneitz, BRRI, 5, p. 7. Quoted by Pusalkar, p. 191.

¹ Trivandrum Plays, Vol. II, p. 32.

depths of heart. But we must go deeper still into the mind of Karna to understand the purpose of Bhāsa's presentation.

Looking to the structure of this playlet it becomes indubitably clear that the aim of Bhāsa is to present a psychological picture as he did in his *Svapnavāsavadattam*. Bhāsa has spread over this canvas the personality of Karna caught in the grip of an inward struggle.

The limitless generosity of Karna is the central fact and the strongest point of his character. But it is also his weakest point. He was easily taken in by Kunti's pleadings. And he allowed himself to be openly robbed by Indra. In discarding the original hint of bargaining, in emphasising and accentuating the mental restlessness of Karna and in thus transforming his character, Bhāsa, I believe, has thrown into prominence this very weakness of Karna's character. Karna has a flair for sheer selfless gifts—a sadistic trait from the point of view of modern psychology. And this interpretation is, indeed, borne out by the fact that Karna is tickled by his own triumph over the beggar.⁸

Bhāsa realised artistically that Karna was a great tragic figure. The source of the tragedy, of course, was Karna's own flair for giving away gifts. Within limits it was a virtue of an exceedingly high order. But Karna possessed this trait and practised it to a fault. And, therefore, like Yudhiṣṭhira's irrepressible desire for dice it was bound to bring about, one day or the other, his own downfall. This is not a construction that I have imposed on the play. It becomes apparent when one reads Bhāsa's text. It is a matter of common knowledge that persons of the type of Karna are unable to realise the weaker, harmful aspect of such a trait in them. In cooler moments they may perhaps be able to realise the harm that they are likely to bring to themselves. But in the heat of the practice or exercise of the trait all such balanced judgment melts away. Did not Yudhiṣṭhira know that gambling was a vice? Yet, when called upon to play he could not refuse. And then, as the heat of the game mounted up to his head, he lost all sense of proportion and pawned away one thing after another, including himself and his wife. This example, deliberately chosen from the same epic source is quite telling in its appropriateness. And it also clearly brings home to us that if we start looking at Karna's generosity from this fresh angle, the generosity reveals the hidden seed of Karna's own self-destruction. Karna practised his virtue to the point of effectual self-effacement, nay, self-immolation. When Indra asked for Kavaca-kunḍala, he was asking for Karna's life. But Karna gave it. This unparalleled act might take Karna to Heaven, but it also brought him death. The genius of Bhāsa, in my opinion, lies in putting a straight finger on this aspect of Karna's generosity which affords the real artistic material for depicting a human tragedy.

It is remarkable to note that Bhāsa has expended much labour and skill on elaborately constructing the Kunḍala-haraṇa episode. He has set the donor and the beggar opposite one another in their distinct individual traits. The beggar wants "mighty alms" (*Mahattarām bhikṣām*) but he does not make a specific demand. The incorrigible donor goes on offering one thing after another. Bhāsa lengthens the dialogue and prolongs the climax. Karna stakes one thing after another, gradually increasing his offer to satisfy the Brāhmaṇa. And as the Brāhmaṇa continues to

⁸ To the remonstrating Śalya, he says : 'शक खलु मया वञ्चितः'

refuse, Karna's blood goes on rising to his temples making him so completely dizzy that he finally parts with his invincible armour and earrings! Karna is prompted by the single, supreme motive of satisfying the demand of the beggar. So great is his own regard for his ability and reputation that nothing stops him in increasing the offers successively made. It is suicide. But Karna would not realise it. Why, even when the whole episode is over and Salya reminds him that he has been cruelly cheated, Karna refuses to accept his defeat: "No, I have duped Indra"—says he, so enveloped he is in the warmth of his own victory over the insatiable beggar. A nobler utterance could not be imagined. But it also lays bare the fountain of self-wrought tragedy! If this is not the meaning and the purpose of the dialogue that Bhāsa has created here, I should like to know why Bhāsa wrote those words. The truth is that Bhāsa saw the tragic potentiality of Karna's character and set himself the task of putting it dramatically. For his artistic purposes it was sufficient to project and emphasise the central tragic trait in Karna. And this he did in the central scene of the meeting between Karna and the disguised Indra. This scene leaves no doubt in our minds that Karna's generosity has brought his inevitable doom on his head, as it was sure to do some day. The psychological death of Karna is clear in our view after this episode. What artistic need is there, then, to show his physical death?

Obviously, Bhāsa is working here through artistic suggestions. Bhāsa's design seems to be to paint the inevitable tragedy of Karna's character on a background that is strikingly suggestive. Now, this background is made up of the following things:

(a) *The Picture of Karna's Own Mental Gloom:*

The soldier who enters after the Prologue has noticed that as Karna steps out of his camp his heart is full of misery. This is rather strange, because a warrior of undoubted heroism like Karna ought to look enthusiastically forward to the prospect of battle.⁹ Karna himself confesses to "The black misery" falling on his mind at the crucial hour of fighting!¹⁰ The love for Pāṇḍavas, his younger brothers, returns to him and he remembers the promise he has given to his mother, Kunti.¹¹

The epic original mentions Karna's dream and the warning of Sūrya. The dream, presented by simple narration, could have fitted here as suggestive of Karna's unhinged mind. Bhāsa has used it in *Bālācharitam* to reveal a similar psychological condition of Karna. But Bhāsa appears to use a varying technique. And I should suppose that the fact that Bhāsa does not utilise the evil omens supplied by the original story but, instead, creates the sense of premonition out of Karna's own mental dejection, is very significant. It is not only more artistic

⁹ Read: 'भो : किंनु खलु युद्धोत्सवप्रमुखस्य दृष्टपराक्रमस्याभूतपूर्वो हृदयसंतापः । एष हि

...अत्युदप्रदीप्तिविशदः समेरप्रगण्यः ।

शौर्यं च संप्रति सशोकमुपैति धोमान् ॥' v. 4.

¹⁰ cf. v. 6 ... 'ममापि वैधुर्यमापतति चेतसि युद्धकाले ॥'

¹¹ cf. vv. 7 and 8. Read particularly ... 'युधिष्ठिरादयस्ते मे यवीयांसस्तु पाण्डवाः' and, 'निरर्थमस्त्रं च मया हि शिक्षितं ।

पुनश्च मातुर्वचनेन वारितः ॥'

because it is more realistic as contrasted with the supernatural suggestions of the epic, but it is manifestly indicative of the fact that Bhāsa is concentrating on the psychological aspect of Karna's character. And this, once more, supports my reading psychological meaning into the play.

(b) *Karna's Narration of the Acquisition of Missiles and the Curse Hanging on Them :*

This is Bhāsa's superb innovation. That Karna should remember the curse at this nick of the moment, is indeed, revealing in its tragic implication. It deepens Karna's mental gloom and accentuates the sense of tragedy that pervades the play.

The narration brings to light several points : There is a testimony to Karna's martial endurance and to his touching devotion to his preceptor in the fact that he remained unmoved, in spite of the worm boring a hole into his thigh, lest the preceptor gone to sleep on his lap, should wake up. It also indicates Karna's worthy ambition to learn and acquire the highest skill in the use of weapons. There is perhaps a reflection on the iniquities that Karna had silently to suffer because of his low social status. There is no reason otherwise why Karna should conceal his origin before his preceptor and tell him a lie. The narration, therefore, creates an amount of sympathy for Karna. But there is also a strong under-current of pathos in the whole thing that cannot be missed. The way poor Karna had to pose for the acquisition of the missiles is pathetic in itself. And the pathos comes to a head when Karna winds up the narration with the statement of the curse. Karna's mind is unhinged. With a pathetic courage he proceeds to examine his missiles. But alas, all power is gone away from them ! His conch-shell and drum have become silent. His horses hopelessly falter. And his elephants betoken retreat.¹² Karna loses all hope. He realises that now he is past protection ! Yet he musters up his valour. He cheers up Śalya who is heart-stricken by the coming doom of Karna.¹³ Karna sets for himself the inevitable reward of a warrior, either heaven or glory,¹⁴ and hopes that his sterling steeds will see him safely through the battle.¹⁵

There is something very touching in this desperate courage of Karna. And there is something pathetically noble in the calm, resigned way he proceeds to meet his doom. Here is Karna's end completely foreshadowed. The narration could be compared to the prophecy of the "walking wood" in Shakespeare's *Macbeth*. The suggestion is unmistakable. And the main scene is still to come where Karna parts away with his Kavaca-Kuṇḍala, and thereby parts away with his life ! Is the play abrupt ?

¹² Read : इमे हि दैन्येन निमीलितेक्षणा मुहुः स्खलन्तो विवशास्तुङ्गमाः ।
गजाश्च सप्तच्छददानगन्धिनो निवेद्यन्तां वरणे निर्वर्तनम् ॥ v. 11.

¹³ cf. Śalya's sentiment, 'अहो कष्टमभिहितं तत्रभवता' after v. 10 ; and
'भोः कष्टं किं नु खल्विदम्' after v. 11.

¹⁴ Read : हतोऽपि लभते स्वर्गं जित्वा तु लभते यशः ।
उभे बहुमते लोके नास्ति निष्फलता वरणे ॥ v. 12.

¹⁵ Read : इमे हि युद्धेष्वनिवर्तिताशा हयाः सुपर्णेन समानवेसाः ।
श्रोमत्सु काम्बोजकुण्डेषु जाता रक्षन्तु मां यद्यपि रक्षितव्यम् ॥
(v. 1. मा यद्यप्यरक्षितव्यम्) v. 13.

(c) *The Sympathy of Śalya :*

I have already remarked that it is of utmost importance to create and stir profound sympathy for the personality that is centrally presented. If there is no sympathy felt for a character his doom leaves one cold and at best the feeling is that he has been served right. One of the essential requisites for a tragedy, therefore, is the unmistakable sense of sympathy for the character whose doom is presented. That is why Bhāsa carefully wiped out the element of dream and Sūrya's request for the demand of a counter gift, and put Karna on a dizzy height of self-effacing generosity. And the companionship of the sympathetic Śalya also comes in accordingly and serves the same artistic purpose. It eschews the discordant note that in the epic original mars Karna's character. The abuses and quarrel that the epic Śalya heaps on Karna definitely shock the foundation of our sympathy; for one wonders whether there is not something really wrong about Karna. And so, in Bhāsa's play, the sympathy of Śalya becomes harmonious with the pathos that the play is full of.

(d) *The Remorse of Indra :*

The picture of the disguised Indra similarly strikes me as full of peculiar significance. I believe that Bhāsa has created a neat little character in this Brāhmaṇa with his peculiar mannerisms, his greed and his irrepressible craving for those things only which are likely to be useful to him. The Brāhmaṇa's continuous refusals to accept the successive gifts of cows,¹⁶ horses,¹⁷ elephants,¹⁸ gold,¹⁹ the kingdom of earth,²⁰ the fruit of Agniṣṭoma sacrifice,²¹—are quite characteristic of the incorrigible nature of a Brāhmaṇa, characteristic of his insatiable desire and of the heartless selfishness. This depravity of the Brāhmaṇa-svabhāva is so strikingly put up in contrast to the boundless nobility of Karna and his incurable desire to satisfy a beggar.

Incidentally, the scene makes us angry with the Brāhmaṇa; it evokes profound pity for Karna; and it also brings forth a sorry laugh as we realise the absurdity and ridiculousness of the whole situation. Bhāsa, I think, has humanised the incident. And in so doing, he has achieved another dramatic effect of first order; a sort of light colour to the grim pathos of the play. And this by contrast, makes the picture more dense.

I should like to believe that in inventing the Deva-Dūta, Bhāsa has added a further human touch to the gift-incident making it more realistic and more moving. It will be realised that, on Bhāsa's showing, Karna's gift of armour and earrings has become the symbol of a donor's triumph over the insatiable and incorrigible beggar. Indra is humiliated and ashamed of himself. For, just as Bhāsa's Karna is different from his prototype of a bargaining donor, even so is his Indra different from

¹⁶ 'गोसहस्रमिति । मुहूर्तकं क्षीरं पिबामि । नेच्छामि कर्ण । '

¹⁷ 'अश्व इति । मुहूर्तकं आरोहामि । नेच्छामि कर्ण । '

¹⁸ 'गज इति । मुहूर्तकं आरोहामि । नेच्छामि कर्ण । '

¹⁹ (कनकं) 'गृहीत्वा गच्छामि । नेच्छामि कर्ण । '

²⁰ 'पृथिव्या किं करिष्यामि । '

²¹ 'अग्निष्टोमफलेन किं कार्यम् । '

the heartless ruffian that we meet in the epic. Any beggar would have been ashamed of himself for taking such a mean and cruel advantage of a magnificent heart of gold. Bhāsa's Indra is naturally filled with remorse. But, in fact, he is not a beggar. He has allowed himself to do that shameful act to oblige the Pāṇḍavas in whom he is interested. This partisan-interest together with the genuine repentance makes Indra so real and human. It is equally important to remember that the idea of the counter gift is born out of this remorse.²² Bhāsa has thus changed the motif of the counter-gift! And in so doing, he has achieved a number of dramatic purposes: The change ennobles the character of Karna. It adds to the conception of Indra's character a real, human and psychological element. And the sympathy of Indra that is unmistakable in his repentance brings a further harmonious touch in the tragic design and deepens the sense of Karna's real tragedy.

(e) *The Repetition of Karna's Command to Śalya* :²³

Woolner writes, "Three times he (Karna) tells Śalya to drive his car where Arjuna is, and the play ends abruptly on that command."²⁴ It is really surprising that the suggestive richness of the sentence should have been so completely missed. It appears that the critics have looked into the play with their minds entirely pre-possessed by the Mahābhārata story, which they held as the norm of their expectations! And having done so, they did not imagine that the dramatist could not only change the borrowed story, but could so metamorphose it as to put new blood and spirit into it. Bhāsa has repeated this sentence three times in this shortest play. The repetition is obviously deliberate and it speaks of Bhāsa's masterly possession of the dramatic sense. Karna, we know, meets his death at the hands of Arjuna. And so the command at once becomes the symbol of Karna's doom. As the play opens, we hear Karna telling Śalya to drive his chariot where Arjuna is: We immediately realise that Karna is on his journey to meet death! The command comes a second time when Karna has tested the futility of his weapons and has forsaken all hope for himself. And finally the play closes with the same command. The repetition of the sentence at these very critical junctures in the play makes the symbol so easily transparent. The play ends with an unmistakable suggestion that Karna has finally closed his account.

Thus, I am finally convinced that in Karna Bhāsa is out not to reproduce or dramatise the epic story. He is creating here the personality of Karna and his method is the method of psychological analysis. With the sure instinct of a dramatist, Bhāsa realised that the central trait of Karna's character was his flair for generosity, which was bound to bring his downfall some day. Bhāsa starts, therefore, to create the inevitable doom of Karna through his character-portrayal. The main vehicle for this creation is, of course, the mental working of Karna himself. From the opening of the play we notice that Karna's mind is weighed down with dismal premonition. Everything that happens now on—the memory of the curse and the realisation of the futility of the missiles—increases the pressure on Karna's mind, though he tries to fight heroically against his falling spirit. But then comes

²² 'देवदत्तः—भो : कर्ण ! कवचकुण्डलग्रहणजनितपश्चात्तापेन पुरंदरेणानुग्रहीतोऽसि ।'

²³ 'यत्रासौ अर्जुनः तत्रैव चोद्यतां मम रथः ।'

²⁴ *Trivandrum Plays*, Vol. II, p. 22.

the parting with the Kavaca-kuṇḍala. And in spite of his pleased smile, Karna, now knows full well that though he has won the battle against Indra, he has lost his battle with life ! It is so plain, therefore, that the "Bhāra" in the title means, "the burden; not the physical, but the *psychological burden*"²⁵—the sense of inevitable doom that weighs on the mind of Karna, and which is worked up through a number of details.

This is Bhāsa's dramatic purpose: to present the impending doom of Karna which flows unmistakably from the central trait of his character. It is this theme that gives the play not only its structural unity, but completeness as well. With the picture of Karna's mental gloom, with the narration of the curse and the futility of the missiles Karna's end is clearly foreshadowed. The symbol of the fateful command, sown at three crucial junctures in the play, turns it, moreover, into a picture of Karna's journey from his camp to his sure death. And the main episode of the Kavaca-kuṇḍala-haraṇa leaves no doubt that a great personality has now come to an end. Consistent with his psychological approach, Bhāsa has left the psychological death of Karna full in our view. That is why the play ends as it does. To show Karna physically sinking down under the volley of Arjuna's arrows would be, not only wantonly needless, but artistically gross and vulgar.

Karnabhāra is, thus, a tragedy also. Already, Woolner has noted that, "This one-Act play has a tragic note..." "It might also be called "Karna's tragedy" or "how Karna drove to his death," for that seems to be what is meant."²⁶ And Ramachandra Rao has elaborately argued the case.²⁷ He has shown on the strength of authentic quotations that it is not essential for tragedy to show the physical death on the stage. I have endeavoured to put the case of Karnabhāra on a different, and, I hope, surer, basis. Karnabhāra is a tragedy of character. Bhāsa has shown us that all the material for Karna's tragedy is inherent in Karna's character. This is exactly what happens in the tragedies of Shakespeare. The ambition of Macbeth, the jealousy of Othello and the fatal hesitation of Hamlet are the respective causes of their undoing. Other factors, supplied by human errors and untoward fate, help to bring the inevitable doom crashing on the hero's head. Of course, Karnabhāra is not a full-fledged drama. It is a dramatic episode, a short one-Act play. But this surely cannot go against it being a tragedy.²⁸ To deny this character to Karnabhāra one must be either incurably prejudiced or ignorant of the fundamentals of tragedy.

²⁵ Bhāsa has used the word "bhāra" in this sense of "mental burden or pressure" in his *svapna*.

Cf. यौगन्धरायणः—(आत्मगतम्) अहो महद्भारमुद्बहति रुमन्वान् । कुतः

सविभ्रमो ह्ययं भ्रातः प्रसक्तस्तस्य तु श्रमः ।

तस्मिन् सर्वमधीनं हि यत्राधीनो नराधिपः ॥ I. 15.

And again, वासवदत्तः—महान् खलु आर्ययौगन्धरायणस्य प्रतिज्ञाभाषे

मम दर्शनेन निष्फलः संवृत्तः । V. 4. 51.

It will appear that even in the meaning 'task' or 'responsibility' the word 'bhāra' does connote the shade of 'mental pressure.'

²⁶ *Trivandrum Plays*, Woolner and Sarup, Vol. II, p. 31.

²⁷ S. Ramachandra Rao, *Tragedies in Sanskrit*, in the Proceedings of the 8th All-India Oriental Conference, Mysore.

²⁸ Pusalkar, among others, writes, "But the Karna is not a tragedy. The notion is due to the misinterpretation of the title." *Bhāsa—A Study*, p. 191,

THE DOCTRINE OF AHIMSĀ IN THE JAINA CANON

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[Continued from p. 118 of Vol. XV, Part 2 (Arts No. 21)]

CHAPTER VI

THE VOWS OF THE CLERGY AND THE LAITY

[Five *mahāvratas* and *anuvratas*, abstention from food and drink at night, *tamaskāya*, implications of the great vows, means of stabilizing the vow—the five *bhāvanās* of *ahimsā*, condition of the *himsaka* and his penalization, four *bhāvanās* such as *maitrī*, etc., *saṃvega* and *vairāgya*, five *saṃitis*, *bhaṅgas* of the first *anuvrata*, types of the *Śrāvakas*, five *aticāras* of the first *anuvrata*, and the differences in the *ahimsā* of the clergy and that of the laity, *ahimsā* in conformity with the life of the *Jaina* laity.]

Five Mahāvratas and Anuvratas—Liberation is the goal of the *Jainas*, and this can be achieved by them by undertaking and sincerely observing the five vows on renouncing the world. These vows are common to those meant for the laity ; but, in the case of the latter they are neither so very comprehensive nor rigid as in the case of the clergy. Thus vows are of two types : (i) great and (ii) small. The five great vows known as *mahāvratas* along with that of abstinence from taking food at night and meant for *Jaina* monks and nuns, are clearly indicated in *Dasaveyāliya* (iv) as under :—

“पढमे भन्ते महव्वए पाणाइवायाओ वेरमणं, सव्वं भन्ते ! पाणाइवायं पच्चक्खामि, से सुहुमं वा बायरं वा तसं वा थावरं वा, नेव सयं पाणे अइवाइज्जा नेवऽनेहिं पाणे अइवायाविज्जा पाणे अइवायन्तेऽवि अन्ने न समणुजाणामि, जावज्जीवाए तिविहं तिविहेणं मणेणं वायाए काएणं न करेमि न कारवेमि करन्तं पि अन्नं न समणुजाणामि, तस्स भन्ते ! पडक्कमामि निन्दामि गरिहामि अप्पाणं वोसिरामि पढमे भन्ते ! महव्वए उवट्ठिओ मि सव्वाओ पाणाइवायाओ वेरमणं ॥१॥ (सुत्त ३)

अहावरे दुच्चे भन्ते ! महव्वए मुसावायाओ वेरमणं, सव्वं भन्ते ! मुसावायं पच्चक्खामि, से कोहा वा लोहा वा भया वा हासा वा, नेव सयं सुसं वइज्जा नेवऽनेहिं सुसं वयंन्तेऽवि अन्ने न समणुजाणामि.....वोसिरामि ! दुच्चे भन्ते ! महव्वए उवट्ठिओ मि सव्वाओ मुसावायाओ वेरमणं २॥ (सुत्त ४)

अहावरे तच्चे भन्ते ! महव्वए अदिन्नादाणाओ वेरमणं, सव्वं भन्ते ! अदिन्नादानं पच्चक्खामि, से गामे वा नगरे वा रणे वा अप्पं वा बहुं वा अणुं वा थूलं वा चित्तमन्तं वा अचित्तमन्तं वा नेव सयं अदिन्नं गिण्हिज्जा नेवऽनेहिं अदिन्नं गिण्हाविज्जा अदिन्नं गिण्हन्ते वि अन्ने न समणुजाणामि.....वोसिरामि ! तच्चे भन्ते ! महव्वए उवट्ठिओ मि सव्वाओ अदिन्नादाणाओ वेरमणं ३॥ (सुत्त ५)

अहावरे चउत्थे भन्ते ! महव्वए मेहुणाओ वेरमणं, सव्वं भन्ते ! महुणे पच्चकरवामि, से दिव्वं वा माणुसं वा तिरिक्खजोणियं वा, नेव सयं मेहुणं सेविज्जा नेवऽन्नेहिं मेहुणं सेवाविज्जा मेहुणं सेवन्तेऽवि अन्ने न समणुजाणामि.....वोसिरामि, चउत्थे भन्ते ! महव्वए उवट्ठिओ मि सव्वाओ मेहुणाओ वेरमणं ४॥ (सुत्त ६)

अहावरे पञ्चमे भन्ते ! महव्वए परिग्गहाओ वेरमणं, सव्वं भन्ते परिग्गहं पच्चक्खामि, से अप्पं वा बहुं वा.....सयं परिग्गहं परिग्गिण्हिज्जा नेवऽन्नेहिं परिग्गहं परिग्गिण्हाविज्जा परिग्गहं परिग्गिण्हन्तेऽवि अन्ने न समणुजाणिज्जा.....वोसिरामि, पञ्चमे भन्ते ! महव्वए उवट्ठिओ मि सव्वाओ परिग्गहाओ वेरमणं ५॥ (सुत्त ७)

अहावरे छेडे भन्ते ! वए राइभोयणाओ वेरमणं सव्वं भन्ते ! राइभोयणं पच्चक्खामि, से असणं वा पाणं वा खाइमं वा साइमं वा नेव सयं राइं भुज्जेज्जा नेवऽन्नेहिं राइं भुजा-विज्जा राइं भुज्जन्तेऽवि अन्ने न समणुजाणेज्जा.....वोसिरामि । छेडे भन्ते ! वए उवट्ठिओ मि सव्वाओ राइभोयणाओ वेरमणं ६॥ (सुत्त ८)”

These suttas 3-8 can be rendered into English as under :—

(I) The first great vow, revered sir, is abstinence from destruction of life—injury to living beings. I renounce, revered sir, all injury to living beings subtle or gross, *trasa* or *sthāvara*. I shall not myself injure living beings, nor cause others to injure living beings nor permit—consent—approve of others injuring living beings. So long as I live, I shall not do this threefold act by mind, speech and body, nor cause another to do it nor consent to another doing it. I retrace, revered sir, from this (sinful) path. I censure it, with myself as the only witness, I censure it in the presence of others (preceptor and the like) and I very much give up (this condition of) my soul.⁶² I have taken up, revered sir, the first great vow. It is (all) abstinence from all injuries to living beings.

(II) Now the next, the second great vow, revered sir, is abstinence from false speech. I renounce, revered sir, all false speech which may be (arising) from anger, greed, fear or mirth. I myself will not tell a lie nor cause others to tell a lie nor consent to others telling a lie. So long as I live.....my soul. I have taken up, revered sir, the second great vow. It is abstinence from all false speech.

(III) Now the next, the third great vow, revered sir, is abstinence from taking what is not given. I renounce in entirety, revered sir, whether in a village or in a city or a forest, taking what is not given, whether it is little or much, small or big, living or non-living. I shall not myself certainly take what is not given nor cause others to take what is not given nor consent to others taking what is not given. So long as..... my soul. I have taken up, revered sir, the third great vow. It is all abstinence from taking what is not given.

⁶² Cf. the following lines occurring in Haribhadra Suri's com. (p. 144a) on *Parasūyāṇīya* :—

“प्रतिक्रामामीति भूताद् दण्डान्निवर्ते अहमित्युक्तं भवति । तस्माच्च निवृत्तिर्यत् तदनुमते-
र्विरज्जगमिति । तथा ‘निन्दामि गर्हामि’ इति । अत्रात्मसाक्षिकी निन्दा परसाक्षिकी गर्हा
जुगुप्सोच्यते । ‘अस्मानम्’ अतीतदण्डकारिणमश्लाघ्यम् । ‘व्युत्सजामि’ इति विविधार्थो विशेषार्थे
वा विशदः उच्छब्दो भृशार्थः सृजामीति त्यजामि । ततश्च विविधं विशेषेण वा भृशं त्यजामि
व्युत्सजामीति । ”

(IV) Now the next, the fourth great vow, revered sir, is abstinence from sexual intercourse.⁶³ I renounce, revered sir, all sexual intercourse whether it pertains to celestial beings, human beings or animals. I shall not myself certainly resort to sexual intercourse nor cause others to resort to sexual intercourse nor consent to others resorting to sexual intercourse. So long as my soul. I have taken up, revered sir, the fourth great vow. It is entire abstinence from sexual intercourse.

(V) Now the next, the fifth great vow, revered sir, is abstinence from possession. I renounce, revered sir, entire possession whether it is little or much, small or great, living or non-living. I shall not myself certainly accept any possession nor cause others to accept any possession nor consent to others accepting any possession. So long as I live the soul. I have taken up, revered sir, the fifth great vow. It is entire abstinence from possession.

(VI) Now the next, the sixth vow, revered sir, is abstention from taking food at night. I renounce, revered sir, all food at night whether *aśana*⁶⁴, *pāna*⁶⁵, *khādima*⁶⁶ or *svādima*⁶⁷. I myself would not take food at night nor cause others to take food at night nor consent to others taking food at night. So long as the soul. I have taken up, revered sir, the sixth vow. It is abstention from all eating at night.

Haribhadra in his com. (p. 150a) on *Dasaveyāliya* (IV,9) says that this *rātribhojana* is mentioned after *mahāvratas* to point out that it is *mūlaguṇa* so far as the *ṛju-jāḍa* (straightforward and full) and *vakra-jāḍa* (cunning and dull) persons of the *tīrthas* of the first and the last *Tīrthāṅkaras* are concerned but it is *uttaraguṇa* in the case the *ṛju* and *prājña* (intelligent) *puṇyās* of the *tīrthas* of the intervening *Tīrthāṅkaras* (i.e. 2-23).⁶⁸

The sixth vow is a corollary of the first great vow. In a way it is included in it; for, in taking meals at night there is every possibility of killing insects, etc., as they cannot be seen for want of proper light, and even if there is light, to ignite a lamp or to have it, is *hiṃsā*. Further, ordinarily, this artificial light is not so very healthy and pervasive as the light of the Sun. So in a place where both are available the latter should be preferred to the former.

⁶³ In *Yogaśāstra* (II, 79) it is said that one should give up sexual intercourse as in this act very very subtle living beings which are born in a *yoni* (uterus) get afflicted and killed. From its com. (p. 121b) we learn that these living beings are *sammūrechima* and are invisible to the physical eye. They get crushed by the male organ, and they die in the way cotton perishes when a heated particle of iron enters a *nālikā* (tube) having cotton inside it. That living beings are produced in a *yoni* is corroborated by the following verse quoted from Vātsyāyana's *Kāmasūtra* :—

“रक्तजाः कृमयः सूक्ष्मा मृदुमभ्याधिशक्तयः ।
जन्मवर्मसु कण्डूतिं जनयन्ति तथाविधाम् ॥”

This verse is incorporated in *Yogaśāstra* as II, 80.

⁶⁴—⁶⁷ These are four types of food. For their explanation see Ch. VII, (p. 87).

⁶⁸ Cf. the following verse of *Uttarajjhayāna* (XXIII) :—

“पुरिमा उज्जु-जङ्घा उ वक्क-जङ्घा य पच्छिमा ।
मज्झिमा उज्जु-पन्ना उ तेण धम्मो बुद्धा कए ॥ २९ ॥”

The value of the five *mahāvratas* noted above is, no doubt, recognized by the Upaniṣadic thinkers, by the *Baudhhas* who call them 'pañca-śīla' and by the *Taugas* who include them under *yama*. The principles of most of these are recognised also in the Christian commandments. But the *Jaina* clergy practices these with a rigour scarcely found elsewhere and hence its importance.

In *Ṭhāṇa* (IV, 1 ; s. 266) four *yāmas* are mentioned. The first three *yāmas* exactly tally with the first three *mahāvratas*, and the last stand for the remaining two *mahāvratas*. In *Āyāra* (VIII, 1 ; s. 197) three *yāmas* are alluded to. Śilāṅka Sūri in his com. (p. 244a) takes these to be *ahiṃsā*, truth and non-possession, the last including non-stealth and celibacy.

• *Tamaskāya*—The Pāīya equivalent 'tamukkāya' occurs in *Ṭhāṇa* (IV, 2 ; s. 291), *Viāhapaṇṇatti* (VI, 5) and *Pavayaṇasāruddhāra* (dāra 255, v. 1401). Of these the first work gives four synonyms, and the last two deal with the nature, extent, etc. From this we learn that *tamaskāya* is a kind of the water-bodied beings. Jainism believes that after sunset during the night-time the water-bodied are as it were raining. The *Jaina* Monks, and nuns and such laymen and laywomen who have taken up the *paṇṣadha* for night cover their body with a blanket when they go out for attending calls of nature. For they believe that thereby the lives of these water-bodied beings get saved.

Implications of the Great Vows—The careful study of the first great vow whereby a *Jaina* monk and a *Jaina* nun undertake to avoid injuring life in its slightest form, will explain why the *Jaina* clergy refrains from touching green plants, unboiled water, fire and light, and avoids using artificial light. The reason underlying this abstention is quite simple : all these forms of life even in their most subtle manifestations are likely to suffer by the touch of the human body.

As regards the second great vow it should be noted that Jainism does not demand, like Western Ethics, absolute truth without regard to its consequences. Truth which undermines the noble and ennobling principle of *ahiṃsā* is a misnomer. Whatever is beneficial to the good is truth.⁶⁰ Consequently that truth which leads to *hiṃsā*, has no place

⁶⁰ Cf. the following verse of *Vīśeṣā* :—

“सच्चा हिया सयामिह सन्तो मुणओ गुणा पयथा वा ।
तविबरीआ मोसा मीसा जा तदुभयसहावा ॥ ३७६ ॥”

From Maladhārīn Hemacandra's com (p. 218) on this we learn : what is beneficial to the *sats* is 'satiya' ; by *sats* are meant sages, *gunas* viz. *mūlagunas* and *uttaragunas* or animae and other substances. What expounds the real nature of substances is *satiya*.

The earliest *Jaina* reference to this *Jaina* view is perhaps one in the *Bhāṣya* (p. 196) on TS (IX, 6). There it is said : “सत्यर्थे भवं वचः सत्यं सद्भ्यो वा हितं सत्यम्”. This is followed by elucidation of truth which is worth noting.

For comparison, etc., see *Truth* by Charles Walston (Waldstein).

Truthfulness is not speaking what is only true, but speaking what is true as well as good and pleasant. For, merely speaking what is true may sometimes descend into garrulity, vulgarity, frivolity, vilification, etc. The fuller meaning of truth which is also wholesome and pleasant is suggested by the word *sūmyā*. Further, for perfect maintenance of this vow, one should conquer anger, fear and greed and even restrain from the habit of jesting.

Sataṇṭha Brāhmaṇa (II, 2, 2. 19) lays stress on *satiya* and one following it, on *rācani-yamatā*.

in *Jaina Ethics*. The second great vow therefore implicitly means that proper care should be taken to see that by speaking truth the higher interests of *ahiṃsā* are not endangered—much less suffer.

In connection with the fourth great vow it may be noted that a *Jaina* monk should avoid even an indirect contact with a woman such as by a carpet, or by a piece of furniture or by a book, etc.

Means of stabilizing the Vow—A vow (*vrata*) is defined in TS (VII, 1) as refraining from—cessation from *hiṃsā*, untruth, stealth, non-celibacy, and possession. If it is partial, it is called small (*aṇu-vrata*); and, if complete, great (*mahā-vrata*). In order to stabilize any one of these vows one should entertain five *bhāvanās* (reflections), ponder upon the evil consequences of *hiṃsā*, etc., here and in the next world, and upon the fact that there is nothing else but misery, and should cultivate four trends of mind (*maitrī*, etc.) and *saṃvega* (earnest desire for salvation) and *vairāgya* (renunciation).

In the case of *ahiṃsā* the five *bhāvanās* are mentioned in *Āyāra* (II, 3; s. 12)⁷⁰, *Pañhāvāgarāṇa* (s. 23)⁷¹ and the *Bhāṣya* (pt. II, p. 44)

⁷⁰ The pertinent portion is as under :—

“इरियासमि ए से निगन्थे, नो अणइरियासमि ए ति । केवली वृया०, अणइरियासमि ए से निगन्थे पाणाई भूयाई जीवाई सत्ताई अभिहणिज्ज वा वात्तिज्ज वा परिआविज्ज वा लेखिज्ज वा उद्विज्ज वा । इरियासमि ए से निगन्थे, नो अणइरियासमि इ ति पढमा भावणा ॥

अहावरा दुच्चा भावणा—मणे परिजाणइ से निगन्थे । जे य मणे पावए सावजे सकिरिए अह्यकरे छयकरे भेयकरे अहिगरणिए पाउसिए पारियाविए पाणाइवाइए भूओवघाइए, तहपगारं मणे नो पधरिजा गमणाए । मणे परिजाणइ से निगन्थे, जे य मणे अपावए ति दुच्चा भावणा ॥

अहावरा तच्चा भावणा—वई परिजाणइ से निगन्थे । जा य वई पाविया सावज्ज । सकिरिया जाव भूओवघाइया तहपगारं वई नो उच्चारिजा । जे वई परिजाणइ से निगन्थे, जा य वई अपाविय ति तच्चा भावणा ॥

अहावरा चउत्था भावणा—आयाणभण्डमत्तनिक्खेवणासमि ए से निगन्थे नो अणायाण-भण्डमत्तनिक्खेवणासमि ए, केवली वृया० आयाणभण्डमत्तनिक्खेवणासमि ए से निगन्थे पाणाई भूयाई जीवाई सत्ताई अभिहणिज्जा वा जाव, उद्विज्ज वा तम्हा आयाणभण्डमत्तनिक्खेवणासमि ए से निगन्थे । नो आयाणभण्ड(मत्त)निक्खेवणासमि ए ति चउत्था भावणा ॥

अहावरा पच्चमा भावणा—आलोइयपाणभोयणभोई से निगन्थे, नो अणालोइयपाण-भोयणभोई । केवली वृया० । अणालोइयपाणभोयणभोई से निगन्थे पाणाणि वा ४ अभिहणिज्ज वा जाव उद्विज्ज वा, तम्हा आलोइयपाणभोयणभोई से निगन्थे, नो अणालोइयपाणभोयणभोई ति पच्चमा भावणा ॥”

⁷¹ The relevant portion is as follows :—

“पाणातिवायवेरमणपरिरक्खणइयाए पढमं ठाणमणगुणजोगजुञ्जणलुगन्तरजिवातियाए दिहि(ः)इ)ए ईरियव्वं कीडपयइगतसथावरदयावरेण तिथं पुप्फ-फल-तय-पद्दाल-कन्द-मूल-दग-मट्ठिय-बीज-हरियपरिवज्जिएणं सम्मं । एवं खल्लु सव्वपाणा न हीलियव्वा, न निन्दियव्वा, न गरहियव्वा, न हिंसियव्वा, न छिन्दियव्वा, न भिन्दियव्वा, न वहेयव्वा, न भयं दुक्खं च किञ्चि लब्भा पावेउं । एवं ईरियासमित्तजोगेण भावितो भवति अन्तरप्पा असवलमसङ्किलिद्धनिव्वण-चरित्तभावणाए अहिंसे संजए सुसाहू ॥

of TS. The last work notes (i) circumspection in walking, (ii) control of mind, (iii) circumspection in searching, accepting and eating food, (iv) circumspection in taking and placing the *upadhi* (accessories) and (v) inspection of food and drink, while accepting it and taking it in daylight as the five *bhāvanās*. These agree with those mentioned in the two *Āngas* I and X. In *Sarvārthasiddhi* (p. 201), too, five reflections are mentioned; but, there is this difference that instead of the third (*esaṅgā-samiti*) we have control of mind.

Over and above the five reflections, some more are noted in TS (VII). For instance, in VII, 4 one is asked to think of the evil and sin pertaining to *hiṃsā*, etc. This is but natural; for a thing which is to be abandoned must be bad; otherwise why should it be at all given up? Further, this idea of abandoning can be maintained, if one goes on meditating upon the defects—faults of the thing abandoned. To take the case of *hiṃsā*, one should reflect upon this that a perpetrator of *hiṃsā* is always dejected and is involved in perpetual enmity. Besides, such a person is subject to beating (*vadha*), tying (*bandha*), harassment (*parikṛśā*), etc. in this world, and, on dying attains *durgati* (a bad grade of existence) and is censured. This is what the *Bhāṣya* (p. 48) on TS (VII, 4) says. In its

बितीयं च मणेण पावणं पावकं अहम्मियं दारुणं निस्संसं बहुबन्धपरिकिलेसबहुलं
भयमरणपरिकिलेससङ्किलिद्रं न कयावि मणेण पावतेण पावगं किञ्चि वि ज्ञायव्वं । एवं
मणसमितिजोगेण भावितो सुसाहू ॥

ततियं च वतीते पावियाते पावले न किञ्चि वि भासियव्वं । एवं वतिसमितिजोगेण
भावितो सुसाहू ॥

चउत्थं आहारएसणाए सुद्धं उच्छं गवेसियव्वं । अन्नाए अगद्धिते अदुद्धे अदीणे अकल्लणे
अविसादी अपरितन्तजोगी जयणघडणकरण चरियविणयगुणजोगसम्पओगजुत्ते भिक्खू भिक्खे-
सणाते जुत्ते समुदाणेऊण भिक्खचरियं उच्छं घेतूण आगतो गुरुजणस्स पासं गमणागमणातिचारे
पडिक्कमणपडिक्कन्ते आलोयणदायणं च दाऊग गुरुजणस्स गुरुसान्निदस्स वा जहोवएसं निरइयारं
च अप्पमत्तो, पुणरवि अणेसणाते पयतो पडिक्कमिता पसन्ते आसीद(न?) सुहनिस्सन्ने सुहुत्तमेत्तं
च ज्ञानसुद्धजोगानणसज्जगोवियमणे धम्ममणे अविमणे सुहमणे अविगमहमणे समाहियमणे सद्धा-
संवेगनिज्जरमणेपवतणबच्छल भावियमणे उट्ठेऊण य पट्टटुट्ठे जहागयाणियं निमन्तइत्ता य
साहवे भावओ य विइणे य गुरुजणेण उपविट्ठे सम्पमज्जिऊण ससांसं सकायं तद्वा करतलं असु-
च्छित्ते अगिद्धे अगाढए अगरहिते अणज्झोववणे अणाइले अलुद्धे अणत्तद्विते असुरसुरं अचवचवं
अदुतमविलम्बयं अपरिसाडिं आलोयभायणे जयं पयत्तेण ववगयसज्जंगमणइगालं च
विगयधूमं अक्खोवज्जणाणुलेवणभूयं सज्जमजायामायानिमित्तं सज्जमभारवहणद्वयाए भुज्जेज्जा
पाणधारणद्वयाए सज्जएण समियं । एवं आहारसमितिजोगेण भाविओ सुसाहू ॥

पञ्चमं आदाननिक्खवणसामई पीढ-फलग-सिज्जा-सन्धारग-वत्थ-पत्त-कम्बल-दण्डग-
रयहरण-चोलपट्टग-मुहोत्तिग-पायपुच्छणादी एयं पि सज्जमस्स उववूद्धद्वयाए वातातवदंस-
मसगसीयपरिरक्खणद्वयाए उवगरणं रागदोसरद्धियं परिहरितव्वं मज्जमेण निच्चं पडिलेहणपप्फो-
डणपमज्जाए अहो य राओ य अप्पमत्तेण होइ सययं निक्खियव्वं च गिण्हियव्वं च भायणभण्डो-
बहिउवगरणं । एवं आयाणभण्डनिक्खेवणासमितिजोगेण भाविओ सुसाहू ॥

Abhayadera Sūri in his cont. on this *Āgama* names these five *bhāvanās* as under :—

(१) ईर्यासमिति (p. 110a), (२) मनःसमिति (p. 110b), (३) वचनसमिति (p. 111a), (४) आहारसमिति (p. 111a), (५) आदाननिक्षेप समिति (p. 112b).

In the above-noted passage there are twelve *upakaraṇas* (accessories) mentioned.

com. (p. 48) by *Siddhasena Gaṇi vadha* is explained as beating by a whip of two *dalas* (cords?), *bandha* as tying with *piṇḍana*, *hadī* (a wooden chain), *nigada* (a fetter), an iron chain and *parikleśa* as holding toes, making one remain in heat, sprinkling with water, placing of wood bricks, etc., hanging, cutting of the head and the like. In TS (VII, 5) the alternative to what was said in VII, 4 is suggested : that *hiṃsā*, etc. are nothing else but misery—pain. Just as pain is not liked by one, so is the case with other living beings. So it is desirable that one should give up *hiṃsā*.

The grand message of *ahiṃsā* preached by one and all the *Tīrthārikas* and promulgated by their apostles, is based upon the following four cardinal virtues known as *bhāvanās* :—

(i) *Maitrī* (amity—love¹³), (ii) *pramoda* (serene joy), (iii) *kāruṇya* (compassion), and (iv) *mādhyaṣṭhya* (detachment).

These are explained in the *Bhāṣya* (pt. II, pp. 56-57) on TS (VII, 6) and by *Siddhasena Gaṇi* in his com. on it. From these we learn : I love one and all. I am a friend of even those who have done harm to me through negligence or otherwise, and they, too, are my friends. So I forgive their faults. It does not matter at all, if any one of them does not forgive me. I have love for all the living beings and have enmity for none—not even for the offender.

To place ourselves in the position of others and to do as we should like to be done by are the main bases of this *bhāvanā*.

One who is endowed with *pramoda* experiences joy when that individual salutes, praises, extols and serves saints who excel that individual in right faith, knowledge, conduct and austerity. This *pramoda* is the delight of the mind, and it is manifested by all sense-organs. In short, the objects of *pramoda* are those who have more virtues than the person experiencing *pramoda*.

Kāruṇya is synonymous with *anukampā* and *dīnānugraha*. So says the *Bhāṣya* (p. 58). *Siddhasena Gaṇi* mentions the following five synonyms for *karuṇā* :—(i) *ghṛṇā*, (ii) *anukampā*¹⁴, (iii) *dayā*, (iv) *kṛpā*, and (v) *dīnānugraha*. Compassion is to be shown towards the afflicted. They are the persons who are overpowered by great infatuation, who suffer from *matyajñāna*¹⁴, *śrutājñāna*¹⁵ and *vibhāṅga-jñāna*,¹⁶ whose minds are being incessantly burnt by the fire of longing for sensuous objects, whose activity for attaining welfare and avoiding unwelfare is misdirected, who suffer from various sorts of miseries, and who are very poor, mean, helpless, foolish, etc. One who is saturated with compassion, obliges such persons by giving beneficial advice, etc.

¹³ Love is the sound principle by which one can eliminate fear, anger, pride and all other divisive emotions and attitudes. Vide *The Power of Non-violence* (p. 69).

¹⁴ "The nobler a soul is, the more objects of compassion it hath"—Bacon.

Śīlāṅka Sūri in his com. (p. 108a) on *Āyāra* (s. 79) shows how the five *saṃitis* are useful for the observance of the five *mahāvratas*. He says : the *īryā-saṃiti* is for protecting the vow of *ahiṃsā*; the *bhāṣā-saṃiti* makes one succeed in maintaining the vow of refraining from telling a lie; *esaṇā-saṃiti* is for guarding the vow of *asteya* (the third *mahāvratā*); and the remaining two *saṃitis* are useful for the successful observance of the vow of *ahiṃsā* which is predominant *par excellence* amongst all the vows,

^{15, 16} For explanation see JRL (Vol. I, p. 113).

Mādhyasthya is same as *audāsīnya* and *upekṣā*⁷⁷ (vide p. 58 of the *Bhāṣya* on TS). This attitude is to be taken in the case of incorrigible persons as no useful purpose can be served by advising them.

If we turn to Hemacandra's *Yogas'āstra* (IV, 118-121) we come across the following four verses which define *maitrī*, etc.

“मा कार्षीत् कोऽपि पापानि मा च भूत् कोऽपि दुःखितः ।
मुच्यतां जगद्व्येषा मातमैत्रा निगद्यते ॥११८॥
अपास्ताशेषदोषाणां वस्तुतत्त्वबलोक्तिनाम् ।
गुणेषु पक्षपातो यः स प्रमोदः प्रकीर्तितः ॥११९॥
दिनेष्वार्तेषु भीतेषु याचमानेषु जीवितम् ।
प्रतीकारपरा बुद्धिः कारुण्यमभिधीयते ॥१२०॥
कूर्कर्मसु निःशङ्कं देवतागुनिन्दिषु ।
आत्मशंसिषु योपेक्षा तन्माध्यस्थ्यमुदीरितम् ॥१२१॥”

By *maitrī* is meant that attitude which makes one desire that none should commit sins, that none should be unhappy and the (entire) universe may attain liberation.

Pramoda means leaning towards—fullest appreciation and admiration for—the virtues of those who have shaken off all the faults and who perceive the essence of objects.

Kāruṇya is the trend of mind which makes one wish to assist those those who are distressed, afflicted, fear-stricken and all those who beg for their lives.

Mādhyasthya is that indifference—leniency one should show towards those who commit cruel acts, who unhesitatingly—openly blaspheme the Deity and (spiritual) preceptor, and who praise themselves—who are extremely arrogant.

It may be noted *en passant* that it is of course meritorious to practise charity wherever our heart is moved to compassion. To build *pāṇjrapoles* for the relief of poor sick animals, to provide the poor hungry with bread, people suffering from cold with clothes and homeless ones with a roof over their heads come under the head of *dravya-dayā*. And as such they do produce merit. But to serve a co-religionist, to fulfil the needs of a saint, to give facilities to those who wish to study scriptures are activities of a higher type than those noted above.

The four trends of mind are known as “brahma-vihāra” in Buddhism, and the great importance is attached to them there. The ninth *pariccheda* of *Visuddhimagga* by Buddhaghosa is named as ‘brahma-vihāra-niddesa’. In its edition (published by the Pali text society) pages 295-314 deal with *maitrī* (Pāli *metta*), and pp. 314-315, p. 316 and p. 317 deal with the remaining three *bhāvanās* respectively. From this it will be seen that *maitrī* is given a very high place, and the rest are as it were its offsprings. These *bhāvanās* are also given a place in *Yogadarśana* (I, 33). The pertinent *sūtra* is :

“मैत्रीकरुणामुदितोपेक्षाणां सुखदुःखपुण्यापुण्यविषयाणां भावनातश्चित्तप्रसादनम्”

⁷⁷ Siddhasena Gaṇi in his com. (pt. II, p. 59) gives *arāgaṇṭṭitā* (absence of attachment) and *adveṣaṇṭṭitā* (absence of aversion) as synonyms of *upekṣā*.

Samvega and *vairāgya* are two other means of stabilizing the great vows like *ahiṃsā*. In this world every one has to experience pain at least to some extent. For, here there is union with undesirable objects and separation from desirable ones. Further, nothing is permanent—not even the relations. This thought leads one to *samvega* which is hankering after salvation on account of fear of mundane existence. Similarly the reflection about the nature of body—its origin, dirtiness, impermanence, etc. rouses the spirit of *vairāgya* (renunciation).

In order to observe *ahiṃsā* one should regulate the movements of the body. To take the case of the clergy, there are five *samitis*⁷³ to be attended to. A *Jaina* monk should therefore walk in such a manner as to cause the least possible injury even to the less developed living beings. This means that he should walk only on barren earth, avoiding the touch of plants and of water, after having carefully examined the way before him. He should not use any kind of vehicle but should go from place to place on foot, and that, too, by day. At night, he should move about, if needs be, by going on sweeping the ground ahead of him, by means of a soft broom so that small insects, etc., if any, may not get trampled under his feet. He should never walk on a carpet; for, he cannot see, much less know, what is below the carpet, and it may be that there are ants, etc., under it, and, if so, he may happen to kill them.

While reading loudly a book or so, a *Jaina* monk or nun should keep a piece of cloth before the mouth. This makes him or her limit the reach of the breath which thereby mitigates its force of injuring the air-bodied. Further, this use of cloth saves a book or so from getting defiled by breath and particles of saliva, when it is perused.

A *Jaina* monk fills a vessel with liquid after ascertaining that it is free from small insects.

Before he sits, he wipes clean the seat. He will never sit down on upholstered furniture, will never use cushions, and never lie down on a mattress lest he might hurt some hidden life.

A *Jaina* monk cannot store up food, etc. If there is any excess left after he has taken his meals in the evening, he should bury it up after properly inspecting the ground concerned.

All the five *samitis* can be strictly observed by the *Jaina* clergy. Nevertheless they have a place, of course, little, in the life of the *Jaina* laity. For a devoted *Śrāvaka* or *Śrāvikā* will avoid treading on green grass so far as possible, will never like to leave a vessel filled with liquid uncovered, will never use an open light lest insects rush into it and get killed, and will ascertain the purity of articles of food before making use of them. Similarly all the three *guptis* which are primarily meant for the *Jaina* clergy can be practised by the devoted laity to an extent permitted by his worldly engagements and commitments.

Bhaṅgas of the first aṇuvrata—Abstention from the *sthūla hiṃsā* is the first *aṇuvrata* of the house-holder. The *hiṃsā* is either committed by oneself (i.e. *kṛta*) or is caused to be committed by another (i.e. *kārita*) or it may be both *kṛta* and *kārita*. Further, each of these types is associated with either one, two or all the three *yogas* viz. mind, body and speech. Hence the *bhaṅgas* of the first *aṇuvrata* are as under :—

(1) *Dvividha-trividha*. One refrains from committing *himsā* both *kṛta* and *kārita*, and, that, too, associated with all the three *yogas*.

(2) *Dvividha-dvividha*. Here, instead of all the three *yogas* there are only two. Thus, there are three varieties.

(3) *Dvividhai kavidha*. Here, instead of all the three *yogas* there is any one of them. So, here, too, there are three varieties.

(4) *Ekavidha-trividha*. Of the two types of *himsā* viz. *kṛta* and *kārita* here there is either from which one refrains, but, of course, by all the three *yogas*. This *bhaṅga* is thus two-fold.

(5) *Ekavidha-dvividha*. This differs from the preceding one in this respect that there are only two *yogas*. They are any two out of three. Thus this *bhaṅga* is three-fold.

(6) *Ekavidhai kavidha*. Out of *kṛta himsā* and *kārita himsā* any one is abstained from. Further, this abstention is associated with only one of the *yogas*, and it may be any one of the three. Thus this *bhaṅga* is six-fold.

These six *bhaṅgās* when thought of, with respect to *karana-trika* viz. *karana* (doing), *kāraṇa* (causing to do), and *anumati*¹⁸ (approval) and *yogatrika* viz. mind, body and speech, come to 49 as under :—

Three *yogas* when taken singly give rise to three varieties. And, so they do, when taken two at a time. When they are taken all at a time there is only one variety. Thus there are 7 varieties so far as the *yoga-trika* goes. Same is the case with *karana-trika* : There are three varieties when taken one at a time, three when taken two at a time, and one when all are taken at a time. Thus, in all, there are 7×7 i.e., 49 *bhaṅgas*. These, when thought of, with respect to the past, the present and the future—the three types of time with which *pratyākhyāna* is associated, come to 49×3 i.e. 147. This is what is expressed in the following *gāthā* quoted in the *svopajña* com. (p. 69a) on *Togaśāstra* :—

“सेयालं भङ्गसयं पञ्चक्खणमि जस्स उवळद्धं ।

सेा खलु पञ्चक्खणे कुसलो सेसा षकुसलाओ ॥”

A house-holder is exempted from *anumati*, for he has a *parigraha* such as children, and when they commit *himsā*, he has to approve of it ; otherwise, if no distinction is made between *parigraha* and *aparigraha*, one who has renounced the world becomes identical with one who has not done so. Here a question may be raised : How is it that in *Viāha-pannatti* etc., the *pratyākhyāna* of a house-holder is said to be ‘*tivihanī tivihanī*’? The reply to this question is given in the *svopajña* com. (p. 68a-b) to *Togaśāstra* as under :—

It refers to a special type of a house-holder who is anxious to renounce the world, or that he is such an individual who takes a vow of refraining from taking the flesh of fish etc. lying in Svayambhū-ocean etc. or from refraining from *sthūla-himsā* etc. owing to a special circumstance.

¹⁸ In *Sāvayadhammavihi* (v. 35) “*anumati*” is said to be threefold : (a) *saṃvāsa* staying together with *mithyādṛṣṭis* (b) *upabhoga* (enjoyment?) and (c) *pratiśravana* (impelling one to do a thing one is doing).

Types of the Śrāvakas—In *Āvassayanijjuttī* (v. 1557) it is said that the *Śrāvakas* are, broadly speaking, of two varieties : (a) *sābhigraha* and (b) *anabhigraha*. But, if we take their sub-varieties into account they are of eight types. These are noted in v. 1559. They can be expressed in Sanskrit as under :—

(1) Dvividha-trividha, (2) Dvividha-dvividha, (3) dvividhai-kavidha, (4) ekavidha-trividha, (5) ekavidha-dividha, (6) ekavidhai-kavidha, (7) uttaragūṇa and (8) avirata.

By 'uttara-gūṇa' is meant one who practices 'uttaragūṇa' viz. three *gūṇa-vratas* and four *śikṣā-vratas*. An *avirata Śrāvaka* is one who has undertaken no vow whatsoever, but, who at the same time is endowed with right faith. Kṛṣṇa, Satyakā and Śreṇika may be cited as examples. Thus one can see that the *sābhigraha Śrāvakas* are of seven types.

The *Niryuktikāra* has not taken into account the case of *trividha-trividha* noted in *Vāhapaṇṇatti* as it is a special case, and that too, of rare occurrence. So says Haribhadra in his com. to v. 1558. Same view is expressed by Siddhasena Sūri in his com. (p. 390a-390b) on *Pavayaṇa-sāruddhāra* of which v. 1322 & fl., mention two, eight, thirty-two and 16808 *bhaṅgas* of the *vratis*—the *Jainas*.

There are six *bhaṅgas* regarding every *anuvrata* out of five. If we add to these thirty *bhaṅgas* two more viz. *uttaragūṇa* and *avirata* we get 32 *bhaṅgas* of *śrāvakatva*.

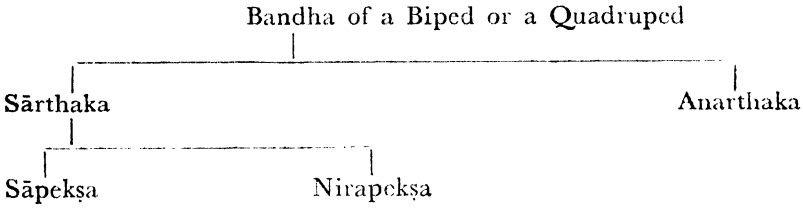
Five aticāras of the first anuvrata—'Aticara' means "partial transgression". There are five such transgressions associated with the first vow of the *Jaina* laity. They are noted in *Uvāsagadasā* (p. 10, §45) as under :—

(i) *Bandha* (tying), *vaha* (beating), *chavicheya* (cutting limbs), *āibhāra* (over-loading) and *bhatta-pāṇa-voccheḍā* (cutting of or reducing food or drink i.e. starving).

In *Āvassaya* (pp. 818a-818b) we come across these very *aticāras*. They are explained in its *Cuppi* (pt. II, pp. 284-285) and in Haribhadra's com. (pp. 818a-818b) on this *Āvassaya* and its *Nijjuttī*. Further, these are mentioned in *Pavayaṇasāruddhāra* (v. 274) and are explained in details in its com. (pp. 71a-72a). *Yogasāstravṛtti* (pp. 189 b-191a) of Hemacandra and *Vandāruvṛtti* (p. 96) of Devendra, too, deal with this topic. From these various sources we learn :—

(I) *Bandha* means tying cows, men, and one's own sons and others by means of a sufficiently long rope or so, on being enraged. Thus tying is two-fold according as it pertains to bipeds or quadrupeds. Each of these *bandhas* may be *sāthaka* (necessary) or *anarthaka* (useless). The latter should not be resorted to. As regards the former, it is of two kinds : (a) *śapekṣa* and (b) *nirapekṣa*. In the *śapekṣa bandha* the tying is loose so that if fire breaks out, the knot can be soon loosened or cut whereas in the *nirapekṣa bandha* tying is very very hard. When a slave or a servant (male or female), a thief, a son neglecting his study or any other biped or a quadruped is tied, it should be seen that there is scope for free movement of the limbs.

This can be represented in a tabular form as under :—



(II) *Vadha* is also like *bandha sāpekṣa* and *nirapekṣa*, and *nirapekṣa vadha* is beating cruelly whereas, *sāpekṣa vadha* means beating in parts other than a vital one by means of a cane or a string, and that, too, once or twice.

If beating is resorted through anger, it is *aticāra* ; otherwise it is not so—it ceases to be so and it becomes *anācāra*.

(III) *Chaviccheda* is also of two kinds *nirapekṣa* and *sāpekṣa*. The former pertains to cutting in a cruel way a hand, a foot, an ear, a nose or the like, and the latter cutting or burning a boil, a pimple, a sore or a wound.

(IV) *Atibhāra*. A *Śrāvaka* should avoid so far as possible earning his livelihood by making a biped or a quadruped bear burden. If he has no other means for his livelihood he should see that the biped is on his back or shoulder loaded with a burden which he himself can place below and in the case of a quadruped the burden must be slightly less than it can be borne by it. Further, this quadruped should be released at the proper time from the plough. If this over-burdening is a result of anger or greed, it is *aticāra*.⁷⁹

(V) *Bhakta-pāna-vyuccheda*. This is also *sārthaka* and *nirarthaka* like *bandha*. The former is again *sāpekṣa* and *nirapekṣa*. The former is for diagnosing a disease. The guilty person should be only told that to-day he would not be given food etc. Ordinarily none should be debarred from taking food or drink ; for, if one is excessively hungry, he may die. If the prohibition is due to anger it is *aticāra* ; if it is with some noble end in view such as for curing a disease, causing *sānti* or so, it is not *aticāra*. For it is said :

“बन्धवद्वहविच्छेदं ब्रह्मरं भतपाणवैच्छेयं ।
कोदाद्वसियमणो गोमण्डमार्दण नो कुण्ड ॥”

This verse is quoted in the com. (p. 71a) on *Parvaṇasāruddhāra*.

In this connection the following objections can be raised :

(1) A *Jaina* who has taken up the first minor vow of refraining from *hiṃsā* is not guilty in case he resorts to tying etc., for, his vow of refraining *hiṃsā* even then remains intact.

(2) When even tying etc. are renounced there is violation of the vow when they are resorted to as it destroys *viratī*.

⁷⁹ Cf. *Pārāśara-smṛiti* (1, 2, 3, 4.) where it is said : An ox who is hungry, thirsty, exhausted, wanting in a limb, diseased and impotent, should not be yoked.

(3) When tying etc. are renounced a fixed measure of the vow in question is not maintained; for, there is an increase in the vows pertaining to *aticāras* per vow. Hence we say that tying etc. are not *aticāras*.

These objections can be answered as under :—

It is true that *hiṃsā* is renounced and not tying etc. But, when the former is renounced the latter get renounced automatically as the latter are means of committing *hiṃsā*.

Even when tying etc. are resorted to, there is no break in the vow, but it is only *aticāra*. For, here the vow is two-fold : internal and external. When one resorts to beating etc. by discarding the destruction of the *prāṇas* of another, on being enraged but without any intention of killing that individual, and this individual does not die, then the vow is broken internally, because his activity disregards the cessation of cruelty but it is observed externally ; for, there is absence of *hiṃsā*. As the vow is thus partially broken and partially observed, the designation 'aticāra' is right.

To say that a fixed measure of the vow is not maintained is unjustifiable. For, there is absence of tying etc., when the pure *ahiṃsā* exists. Hence it follows that tying etc. are nothing else but *aticāras*.⁸⁰

The use of *mantra*, *tantra* etc. should be looked upon as *aticāra*, for this is implied in tying etc.

Vikathā is of four kinds : (i) *strī-kathā*, (2) *bhakta-kathā*, (3) *deśa-kathā* and (4) *rāja-kathā*. Their subject-matters are : (a) women, (b) food, (c) country and (d) ruler respectively. Further, each of these *kathās* is again four-fold. The four varieties of *strī-kathā* are associated with caste (*jāti*), family (*kula*), beauty (*rūpa*) and dress (*nepathya*) of the woman respectively. For instance, in the *jāti-kathā* a Brāhmaṇi or a woman of some other caste may have been praised or denounced.

Bhakta-kathā is of four types according as it refers to *dravya* (say clarified butter), special vegetables, preparation from goats, partridges etc. (छागतिस्तिराद्यारम्भ etc.) and the value of the dishes.

Deśa-kathā is four-fold ; for it may refer to either *chandas*, *vidhi*, *vikalpa* or *nepathya*.

Differences in the ahiṃsā of the Clergy and that of the Laity—There are two respects in which the first vow of the clergy differs from that of the laity :—

(1) The monk or the nun renounces *hiṃsā* in three ways i.e. he or she takes the vow of (a) not committing *hiṃsā* by oneself, (b) not to cause others to do so and (c) not to consent to others doing so, whereas the *Jaina* layman or the lay-woman abstains from the first two types only. Thus the *hiṃsā* of the clergy is associated with all the three elements viz. *kṛta*, *kārita* and *anumata* whereas that of the laity with only the first two.

⁸⁰ This topic is given in Pāiṇya in *Kahāraṇyakosa* (p. 243 b) composed by Devabhadrā Sūri in *Samvat* 1158.

(2) The *ahimsā* that can be at best observed by the *Jaina* laity is one sixteenth of what the clergy can observe. In the case of both the clergy and the laity there is no room for the *himsā* of the subtle *sthāvara*; for, they die only a natural death and can never be killed.

The clergy abstains from committing *himsā* of the gross *sthāvara*, but the laity as such cannot do so. Further, the laity cannot abstain from the *himsā* of all the *trasa* beings guilty and non-guilty as well, as the laity cannot help punishing the guilty *trasas*.⁸¹

From this exposition it must have been clear that *ahimsā* which a *Jaina* layman is expected to observe does not prevent him from defending himself or his own family. As stated in *An Interpretation of Jaina Ethics* (p. 22) it gives him "ample freedom to fulfil all his worldly duties and to remain in fullest concordance with worldly propriety and etiquette, even if he happens to be a judge, or a king even, or to occupy any other responsible post which requires energetic and even violent acting, in the interest of the state".

Further it does not debar him from resorting to certain activities which involve injury to lower life, the activities "such as the construction of houses or wells, the gathering of fruits and vegetables and their preparation, the use of vehicles etc. etc."—*Ibid.* pp. 22-23.

The *Jaina* view about *dravya-himsā* and *bhāva-himsā* along with the standard of rigour expected from the laity regarding the abstinence from *himsā*, clearly answers the following two questions raised in *Gṛhalakṣmī* (part iv, p. 16) :

(१) "सुं हिंसा जगतने जरूरी छे?"

(२) "हिंसक जगतमां हिंसार्था बचवा मोटे अंशतः हिंसा जरूरी नथी?"

They mean : (i) Is *himsā* necessary in the world? (ii) Is it not necessary to commit *himsā* to some extent with a view to refraining from *himsā* in this *himsāka* world?

We shall end this chapter by quoting the following lines from "The Heritage of the Last Arhat" (pp. 5-6):—

"This explains why the saying 'ahimsā paramo dharmah' i.e. non-injury is the highest of all religious principles, acts such an important part in the daily life of the religiously inspired *Jaina*, whose sensible heart a physical galvanometer, as it were, warns him of every disturbance of well-being in the community of fellow-creatures around him and spontaneously causes him to insert the resistance of self-control in the circuit of his own activity, or to restrain that of others in its proper course."

CHAPTER VII

AHIMSA AND THE LIFE OF THE JAINAS

[*Ahimsā* as an article of faith, diet of the *Jainas*, prohibition of flesh-eating, four types of food, twenty-two *abhakṣyas*, diet of the some of the *Ājīvikas*, hermits and others, dress, foot-wear and occupations of the *Jaina* laity, true bath, ten types of donation, shower of flowers in *samavasaraṇa* and killing of the *himsra* beings, kindness to lower animals, and hunting, etc.]

⁸¹ For particulars see JRL (ch. XIX).

Ahiṃsā is an article of faith in the case of each and every *Jaina*, whether that individual is *avirata* (vowless) or *virata*. The former class of individuals is really sorry for the *hiṃsaka* life it have to lead. The latter class consists of two groups according as *ahiṃsā*, both intensive and extensive, governs its life partially or wholly. Even persons belonging to the first group so mould their life that their diet, dress, foot-wear, occupation etc., are quite consistent with their vow of *ahiṃsā*, though small. Such being the case, each and every activity of the *Jaina* clergy—their tour, talk, begging and acceptance of food, costume etc., distinctly points out their *ahiṃsaka* attitude towards life and furnishes us with a model of etiquette⁸³ which an ideal society may expect from them.

Diet—The diet of a vowless *Jaina* may be non-vegetarian⁸³ (but, in practice, it is not so, so far as the *Jainas* of today are concerned). But it can never be so in the case of the *Jaina* clergy who takes food not for the relish of it, nor for acquiring physical strength but who does so, simply to sustain the body, an instrument useful for purifying the soul encased therein. Even a *Jaina* house-holder who has undertaken the small vow of *ahiṃsā* is all the while anxious to take a vegetarian diet and to refrain from taking flesh, fish and even eggs. There is a reason for it. Vegetation is less developed than fishes or birds or beasts. And the higher the stage of development of the injured being is, the heavier is the sin committed in depriving it of its life.⁸⁴ It is from this standpoint that Jainism forbids flesh-eating,⁸⁵ and, on the other hand, objects little to the eating of vegetables. Here, too, there are certain restrictions which govern even the life of the *Jaina* laity. Before I mention them I shall deal with the four types of food which the *Jaina* clergy abstains from, at night, without fail.

⁸³ See Dr. B. C. Iaw's article "Jain Rules of Etiquette" published in "Jaina Antiquary" (Vol. XI, No. 11).

⁸³ In *Rgvedic Culture* (p. 203) it is said: "Māṃsa or flesh was a regular food of the Vedic Aryans."

This is supported by alluding to topics noted in *Rg-veda* (I, 162, 3, 10, 11; I, 162, 12; I, 162, 13; II, 27, 5; V, 29, 7, 8; VI, 16, 47; VI, 17, 11; VIII, 43, 11; X, 27, 2; X, 89, 14), *Aitareya Brāhmaṇa* (I, 3, 4), *Satapatha Brāhmaṇa* (III, 1, 2, 21; III, 4, 1, 2) and *Vājasaneyi Samhitā* (I, 109).

⁸⁴ Dr. Charlotte Krause says in *An Interpretation of Jain Ethics* (p. 9):—

"The sin of hurting a plant is smaller than that of hurting a lizard, the sin of hurting a bullock is smaller than that of hurting a man, and the sin of hurting a criminal is relatively smaller than that of hurting a Śādhu."

This very idea is expressed by her in *The Heritage of the Last Arhat* (p. 11) as under:—

"According to the principle of economy, the higher developed ones are higher valued than the lower developed ones. Therefore the karma bound by harming a higher developed being is thought to be of graver consequences than that bound by injuring a lower creature. Thus, plucking a handful of vegetables is by far, less harmful than killing a cow; killing a menacing tiger less harmful than the murder of a peaceful antelope; or punishing a dangerous criminal is of less consequences than an offence done to a saintly monk."

⁸⁵ Rev. Mr. E. O. James in his *Introduction to Anthropology* (1919), pp. 65-66 says:

"Homo primigenius was probably at first mainly a vegetarian, till through the deficiency of the food-supply caused by the advancing glacial period (in Europe), he was obliged to acquire flesh-eating propensities, and thus added animal food to his original diet. . . . It can be pretty safely assumed, judging from the teeth of the earliest skulls and from the lack of implements that prior to the Chellean Age primeval man was chiefly a vegetarian, except for such flesh as was furnished by small animals."

—Quoted from *Rgvedic Culture* (p. 49).

Orphius had preached that one should abstain from flesh, beans, particular types of fish and sacrifices involving *hiṃsā*.

Pythagoras had emphasized that one should give up flesh.

Sabjāni, a Sufi of the 17th century did not eat flesh.

Four types of food—*āhāra* is said to be fourfold: (a) *aśana* (P. *asāṇa*), (b) *pāna* (P. *pāṇa*), (c) *khādima* (P. *khāyima*) and (d) *svādima* (P. *sāyima*). These four words are derived from the roots \sqrt{as} , $\sqrt{pā}$, $\sqrt{khād}$ and $\sqrt{svād}$ respectively. Their etymologies as based upon *Avassaya-nijjuttī* (v. 1588) are noted by Siddhasena Sūri in his com. (p. 50b) on *Pavayaṇasāruddhāra*. They mean :

- (i) One that quickly gratifies hunger is 'aśana.'
- (ii) One that obliges *pāṇas* such as sense-organs etc., is 'pāna.'⁸⁶
- (iii) One that is contained in the hole of the mouth—the sky, is 'khādima.'
- (iv) A substance like treacle that makes one taste qualities such as *rasa* is 'svādima'. Or one that makes taste the merits of the doer (by showing his control over the senses) is 'svādima'. Or one that destroys one's own qualities such as sweetness while being tasted is 'svādima.'⁸⁷

Abhayadeva Sūri in his com. (p. 220a) on *Thāṇa* says :

“अश्नत इत्यश्नम्—भोदनादि; पीयत इति पानम्—सौवारादि; खादः प्रयोजनमस्येति खादिमम्—फलवर्गादि; स्वादः प्रयोजनमस्येति स्वादिमम्—ताम्बूलदि”

In *Pavayaṇasāruddhāra* (v. 207-210) there are examples of each of these four varieties, and some more are mentioned in the com. From these two sources we learn :

Aśana comprises cooked rice, *saktu* i.e., flour of barley fried and then ground (*sāthavo* in Guj.), *mudga* ('maga' in Guj., a kind of kidney-bean), *jagāri* ('rāba' in Guj.), *khādyaka* ('khājum' in Guj.), *mandikā*, *modaka* (sweet ball), *sukumārikā*, *ghṛtapūṛaka* ('ghebara'⁸⁸ in Guj.), *lāpaśrī* ('lāpaśī' in Guj.), *svargaṇṇapūtā*, *kṣīra* (milk), *dadhi* ('dahi' in Guj., thick sour milk), *ghṛta* (clarified butter, 'ghee' in Guj.) butter-milk, *timana*, *rasāla*, *sūraṇa* (an esculent root), ginger and other vegetables, *maṇḍaka* (a kind of baked flower), *thoṭhika*, *kullarikā*, *cūriyaka* and *idḍarikā* (? *idaḍā* in Guj.).

Pāna consists of sour gruel, water of *yava* (barley), wheat, *ṣaṣṭhikā* ('sāthī' in Guj.) rice, *koḍrava*, liquor, *śaraka*, water of lake, river, well, etc., water of *karkatāka* (cucumber, 'kākaḍī,' in Guj.), and *cirbhūṭaka* ('cibhādum' in Guj.), *rasa* (juice), dates, grapes, *ciñciṇikā* and sugar-cane.

Khādima comprises *bhaktauṣa* such as baked gram, wheat, etc., *dantya* i.e., *gunda* or some preparation having treacle,⁸⁹ *cārukulikā* ('cāoli' in Guj.), *khaṇḍa*⁹⁰ (sugar), sugar-cane, *śarkarā* (candy-sugar⁹¹), dates, cocoanuts, grapes, *akṣatakas* (walnuts), *badāmas* (almonds), cucumbers, mangoes, *panasas* (jack-fruits) and bananas (plantain-fruits).

⁸⁶ This meaning is derived by taking into account the Pāli word "pāṇa."

⁸⁷ This interpretation is based upon the Pāli root 'sāya' in "sāyima."

⁸⁸ Kumārāpāla once referred to Hemacandra Sūri if he could eat "ghebara". Thereupon he was asked by the Sūri to give up eating it as it reminded him of a corresponding non-vegetarian dish.

^{89—91} For their synonyms and varieties see my Guj. article गेळ, खांड अने साकर published in JSP (Vol. XII, No. 4, pp. 111—114).

Svādima consists of *dantapāvana* (tooth-brush), *nāgavallī* (betel-leaf), *areca-nut*, *jāti-phala* ('jāyaphala' in Guj., nutmeg), *tulasī*, *kuṣṭhaka* (viscous ginger), *jiraka* jirum in Guj., cumin seed), *harita*, *madhu* (jethi-madha in Guj.), *pipplā* (long pepper), treacle, *marica* (black pepper), *ajmoda* (ajamo in Guj.), *sunṭhi* (dry ginger), *haritaki* (yellow or chebulina myrobalan haraḍe in Guj.), *bhibhitaka* (beleric myrobalan, 'bēḍā in Guj.), *āmalaḱā* (myrobalan, 'amālān' in Guj.) and *kaṭubandha*.

Twenty-two abhakṣyas—In *Pavayaṇasāruddhāra* (v. 245-6) the following twenty-two things are mentioned as worth refraining from :

(1-5) Fruits of the five types of 'udumbara' trees viz., a banyan tree, *pipplā* (the holy fig tree), *udumbara* (kind of fig tree), *plakṣa* (kind of fig tree) and *kākodumbārī* (kind of fig tree), (6-9) four *vikṛtis* viz., liquor⁸², flesh, honey and butter, (10) snow, (11) poison, (12) *karaka* (hail), (13) all types of clay, (14) meals at night, (15) those that contain many seeds, (16) *anantakāyas*, (17) *sandhāna* (pickle) (18) *gholavatakas* ('gholavada' in Guj.) (19) fruits of egg-plant, (20) fruits and flowers of unknown names, (23) *tuccha* fruits (fruits of which the eatable substance is far less than one to be discarded), and (22) *calita rasa*.

In the com. (pp. 58b-59a) on this work the reasons why these twenty-two articles are forbidden are given. They are :

(1-5) Fruits of the five types of fig-tree are to be avoided as they are full of small living beings having the shape of a mosquito.

(6-9) The four *vikṛtis* are unfit to be taken since *sammūrcchima jīvas* of their colour are immediately produced in them.⁸³

(10) Snow is not to be taken as it comprises *asaṃkhyāta* (innumerable) *uddha* water-bodied beings.

(11) Poison is to be avoided ; for, even, if its efficacy is counteracted by a *mantra*, it causes destruction of *gaṇḍolakas* (kind of worm, *gaṇḍolā* in Guj.) and other living beings inside the belly, and further, it causes great infatuation at the time of death.

(12) *Karaka* consists of *asaṃkhyāta* water-bodied beings. So it should not be taken.

(13) All sorts of clay including *khaṭikā* ('khaḍī' in Guj.) should be taken as they are instrumental in generating five-sensed beings like frogs, and, as it involves a fault of resorting to raw materials.

(14) Meals at night should be avoided as there is a possibility for fall of many living beings therein, and as it is bad on account of its being faulty here and in the other world.

(15) Articles having many seeds such as *pamṇas* etc., if taken, mean the destruction of many living beings ; for, there is life per seed.

⁸² According to *Bodhāyana-smṛti* (I. X, 18, 18) 'the drinking of spiritual liquor was a heinous crime on the part of a Brahmin and he was to be branded with the sign of a tavern and banished'. Vide *Evolution of Hindu Moral Ideas* (p. 113).

⁸³ In *Mamu-smṛti* (V, 45-55) various grounds are mentioned for disapproving the use of meat : its unobtainability without injury to living beings, its disgusting origin, and cruelty of fettering and slaying corporal beings. But, strange to say, in the course of this very *adhyāya* we come across several verses recognizing the lawfulness of animal food without any attempt at reconciliation.

(16) *Anantakāyas* should not be taken as it would lead to the annihilation of *ananta jantus*.

(17) *Sandhāna* also known as *astyānaka* (Guj. 'aṭhāṇum') of *bilvakas* (bīluṇ in Guj.) etc., should be avoided; for it is a cause of the *saṃsakti* of living beings.

(18) *Gholavaṭakas* and *dvidalas* mixed with raw *gorasa*⁹⁴ are to be avoided as they are likely to lead to the *saṃsakti* of *sūkṣma jīvas* knowable to the omniscient.

(19) Fruits of the egg-plant should not be eaten, for it leads to much sleep and excites passions.

• (20) Fruits and flowers of which names are not known, should not be taken; for, one of these flowers or fruits may be the very one which ought to be avoided, and so, if taken, it breaks the vow. Further if it is poisonous it may cause death.

(21) By *tuccha* fruits are meant those of *madhūka*, *bilva* (bīli in Guj.) etc., By implication are meant leaves of *tandulikas* produced in the rainy season.

Tuccha fruits may mean *cavalaka*, *śimba* etc. which are half ripe and tender. By eating such fruits there is no satisfaction, and, on the contrary it leads to many faults.

(22) 'Ālita rasa' means *kulhitāṇna* i.e., food in a rotten condition. It refers to *puṣpita odana* (rice with phūga i.e., mould)? Curds of more than two days standing, should be also avoided as it is likely to lead to *himsā*.

Diet of the Ajivikas—In *Viāhapannatti* (VIII, 5; s. 330) it is said that the twelve adherents of the Ajivika school abstain from eating five kinds of fruits *viṭṭ*, *umbara*, *vada* (bunyan) *bora* (jujube fruit), *setura* (mulberries) and *pīlāṅku* and from onions, garlic, bulbous roots etc.

In *Sūyagaḍa* (I, 7, 12) it is said : Some foolish persons say that liberation is attained by giving up salt, some say by resorting to cold water, and some say by oblations.

Śilāṅka in his com. (p. 159b) on it notes a variant for 'आहारसम्पञ्जन-वञ्जणेण' viz., 'आहारो पञ्चकवञ्जणे' and explains it as garlic, onion, milk of a she-camel, beef and wine.

Diet of the hermits and others—*Viāhapannatti* furnishes us with information regarding food taken by hermits and others. For instance, the *Bāla-tāvasas* live only by eating leaves that fall off naturally from trees (I, 2-25) and the *Uṭṭahadanturakkhalīyas* live on fruits and use their teeth as mortar (XI, 9; s. 417). The *Ambubhakkhis* live on water only, the *Vāyubhakkhis* on air only, the *Sevalakkhakkhis* on moss only, the *Mūlāhāras* on roots only; the *Kandāhāras* on bulbous roots only, *Tayāhāras* on barks only, the *Pattāhāras* on leaves only, the *Puphāhāras* on flowers only, the *Phalāhāras* on fruits only, the *Biyāhāras* on seeds only, and some on rotten bulbous roots, roots, flowers and leaves (XI, 9; s. 417).

⁹⁴ It implies three things : (i) a cow's milk, (ii) curds and (iii) butter-milk,

As stated in *Oṃvāya* (s. 73) the *Dagabīyas* take water as the second item in the meal. According to *Anugaddāra* (s. 20) the *Bhikkhūḍas* eat nothing except what has been obtained as alms and will not take milk unless it had been milked by another.

These particulars regarding diet suggest the trends of thought of different classes of hermits and others who wanted to have their food as far free from *hiṃsā* as possible.

Dress and foot-wear.—Even a *viyata* *Jaina* layman willingly undertakes to cut short his requirements and possessions. Then what to say about the *Jaina* monks and nuns? They have no possession, nothing which they can claim as *their* property. Just as they get food by begging so do they get cloth to wear. Their dress is very very simple. Popishness has no place in their life. They have nothing to do with foot-wear; for they go bare-footed even though they travel on foot. They keep no umbrella to protect themselves from heat or rain. The case of the *Jaina* laity is otherwise. Nevertheless their dress, foot-wear etc., are expected to be such as are consistent with their vow of *ahiṃsā* and also with their age, status etc.

Occupations.—A *Jaina* who has undertaken twelve vows should try to maintain himself and his family by better occupations than those which involve a great deal of slaughter of living beings such as butchery, brewery, gun-making etc. The occupations which he should avoid as far as possible are known as fifteen *karmādānas*, as they generate *karman*. They are : (i) burning a kiln, (ii) cutting jungles, (iii) selling carts, (iv) receiving hire, (v) digging the earth, (vi) trading in ivory etc., (vii) dealing in sealing wax, (viii) trading in liquid things, (ix) selling bipeds and quadrupeds, (x) selling poison, (xi) working with a machine, (xii) mutilating or cutting limbs of an animal, (xiii) burning jungles, (xiv) drying up water of a lake and the like and (xv) taming obnoxious animals etc.

The true bath.—In *Uttarajjhayana* (XII) there is a discussion about true bath. A saint is asked a question: Which is your reservoir? Which is your *śānti-tīrtha*? And what is that place wherein on taking bath you remove dust? (45).

The answer is: *Dharma* is my reservoir. Celibacy is my holy place. On taking bath in the praise-worthy and pure *leśyā* of the soul I become clean and purified (46).

This bath is seen by the *ku'alar*. This is the great bath praised by sages. The greatest sages on taking this bath have attained the highest abode (47).

Śīlāṅka in his com. (p. 120a) on *Āyāra* says : Bathing with water does harm to the *yatis* and the celibate. He supports it by quoting the following verse :

“स्नानं मददर्पकरं कामाङ्गं प्रथमं स्मृतम् ।
तस्मात् कामं परित्यज्य नैव स्नान्ति दमे रताः ॥ ”

This quotation with the variant न ते for नैव occurs in his com. (p. 160a) on *Sūyagada* (I, 7, 14).

As regards true bath he quotes a verse as under :

“नोदकीकृन्नगात्रो हि स्नात इत्यभिधीयते ।
स स्नातो यो व्रतस्नातः स बाह्याभ्यन्तरः शुचिः ॥ ”

This means : one whose body is made wet by water is not called “snāta”; he who has taken a bath of vows is “snāta”, and he is pure externally and internally as well.

Dayā—*Dayā*, *karuṇā* etc., are synonyms, and their English equivalents are mercy, compassion etc. *Dayā* (compassion) is of two types : (i) *dravya-dayā* and (ii) *bhāva-dayā*. To entertain a thought of removing misery of the afflicted is *dravya-dayā* whereas the attitude of improving the condition of a sinner is *bhāva-dayā*.

Dāna—In *Thāṇa* (X; s. 745) ten types of *dāna* are mentioned :—

“अणुकम्मा १ सङ्गाहे २ चेव भये ३ कालुणितेति य ४ ।
लज्जाते ५ गारवेण च ६ अहम्मे उण सत्तमे ७ ॥
धम्मे त अग्गे वुत्ते ८ कादीति त ९ कर्तेति त १० ॥ ”

These types are the outcome of the ten motives : (i) compassion, (ii) assistance to the distressed, (iii) fear of the ruler and the like, (iv) grief, (v) bashfulness lack of saying no flatly, (vi) glorification—satisfying one's pride, (vii) help to the irreligious, (viii) fulfilment of the needs of the deserving, (ix) desire of being obliged and (x) return of previous obligation.

Shower of flowers in a samavasaraṇa—In every *samavasaraṇa* constructed by celestial beings, gods discharge a shower of full-blown flowers with their stalks below and faces upwards. These are of five colours and are such as are produced on earth and in water. The shower is knee-deep. So persons coming to the *samavasaraṇa* and going from it have to pass through—as it were to wade through these flowers. So a question arises as to their molestation at the hands of monks who come to the *samavasaraṇa*. This question is fully discussed as under by Siddhasena Sūri in his com. (p. 107a-b) on *Paṇḍarāśāśuddhāra*. He raises two questions as under and then answers them :—

(i) How do the monks whose hearts are full of compassion for living beings, perform various activities such as staying, going, etc., when there are flowers in the *samavasaraṇa* ?

(ii) Do not these activities lead to the destruction of lives in flowers ?

Some answer these questions by saying that these flowers are lifeless as they are constructed by gods. But it is not sound; for, over and above the artificial flowers created by gods there are other flowers produced on earth and in water. So says the *Āgama*. The pertinent *gāthā* is as follows :—

“बिंदद्राई सुरभि जलधलयं दिव्वकुसुमनीहारिं ।
पयारिति समनेणं दसद्ववणं कुसुमवुद्धिं ॥ ”⁹⁴

⁹⁴ This verse beginning with *वेदद्राई* instead of *बिंदद्राई* occurs as v. 546 in *Avassayanijjuttī*.

On being reminded of this *gāthā* some reply : gods do not shower flowers in a place where the *vratis* (those who have taken a vow) stay. This, too, is no reply; for, the monks and others do not remain unmoved in one and the same place like a block of wood ; they do stir out when needed. So the real answer to this question as accepted by one and all the *gītārthas* is : just as there is no mutual inconvenience caused to persons attending a *samava-araṇa* in spite of the overcrowding of hundreds of gods and other beings there, so, in this case, too, there is no molestation of flowers, though several monks and laymen pass through them. On the contrary, these flowers derive joy which they would, when sprinkled with nectar. This is, of course, due to the *atiśaya* (excellence) of the *Tīrthaṅkara* concerned.

Himsā of the himsra (injurious) beings—In the *svopajñā* com. (p. 70a) on *Yogaśāstra* (iv. 9-12) the view of those who advocate killing of the injurious living beings is noted.⁹⁵ It can be summarised as under :—

Some say that those living beings who kill others *e. g.*, carnivorous animals, should be killed; for, when one *himsra* being is killed certainly it causes protection to many. But this is not proper; for, in this world each and every living being is *himsra*. Besides if *dharma* has its origin in *ahimsā*, how can it be attained by practising *hiṃsā*? Lotuses which are born in water cannot be produced from fire (on the contrary they get destroyed by fire). *Himsā* is the cause of sin. So how can it destroy sin? *Kālakūṭa* (poison) which is the cause of death, cannot give life.

Kindness to lower animals—Even the *Jaiṇa* laity is kind towards lower animals.⁹⁶ Then what to say about their saints whose kindness knows no bounds as it extends to even one-sensed beings—the whole sentient creation? An ordinary Hindu will be amazed and feel proud to learn that “in the history of western Ethics, too, some regard has been shown to lower animals in their relation to human conduct.”⁹⁷ In *History of European Morals* (Vol. II, p. 1166) we have :

“Casting aside the dogma of transmigration, or at least speaking of it only as a doubtful conjecture, he⁹⁸ places the duty of kindness to animals on the broad ground of the affections, and he urges that duty with an emphasis and a detail to which no adequate parallel can, I believe, be found in the Christian writings⁹⁹ for at least seventeen hundred years. He condemns absolutely the games of the amphitheatre, dwells with great force upon the effect of such spectacles in hardening the character, enumerates in detail, and denounces with unqualified energy, the refined cruelties which gastronomic fancies have produced, and asserts in the strongest language that every man has duties to the animal world as truly as to his fellow-man.”

In *Evolution of Hindu Moral Ideals* (p. 185) there is a following remark to which I subscribe entirely :—

“It is absurd to suggest, as has been done by some writers on comparative ethics, that this duty of kindness to the lower animals is connected with the doctrine of transmigration of souls or with what has been described as zoolatry.”

⁹⁵ In *Manu-smṛiti* (XI, 131-134) it is said : for killing a snake, a *Brāhmaṇa* shall give a spade of black iron, for killing a eunuch, a load of straw and a *māsa* of lead, for killing carnivorous wild beasts the offender should give a milch cow to a *Brāhmaṇa*.

According to *Gautama-smṛiti* (XXII, 27) no penance is necessary for killing a harlot.

⁹⁶ Tender interest in animal life is one of the most distinctive features of the poetry of Virgil.

⁹⁷ Vide *Hindu Ethics* (p. 223).

⁹⁸ By “he” is meant “Plutarch.”

⁹⁹ For the attitude of Christianity towards lower animals see *The Origin and Development of Moral Ideas* (Vol. II, pp. 506-514) by E. Westermarck.

Hunting etc.—Hunting is an antiquated form of amusement, belonging to the days of bull-baiting and cock-fighting.¹⁰⁰ No gentleman now wishes for the resumption on its formal scale of the hateful cruelty involved in worrying foxes, hares, otters, and deer until they are half-dead from exhaustion and then finishing them off by letting them (all except the deer) be torn to pieces by hounds. If any one says that sometimes the hunted escape, I say they very often escape with lungs irreparably injured and other organs or limbs painfully damaged. I completely agree with Hamilton Fyfe, President of the 'League against Cruel sports', when he says :

"Look at it how you will, the worrying, chasing and hideous slaughtering of animals for fun is abominable, inhuman, not to be any longer endured."¹⁰¹

None should torture or kill animals for fun. Some naughty boys take delight in tying a tin-box or so to the tail of the donkey. But this is their stupidity, and it shows lack of humanity on the part of their parents or guardians, if they tolerate this ill-treatment of the donkey and the like, even when they come to know about it.

A *Jaina*, worth the name, cannot think of taking delight in hunting, shooting, fishing, etc., when they are resorted to, for the sake of mere fun. Even the law does not allow shooting of a doe and hunting of a species when it may go to the length of its extermination.

CHAPTER VIII

ATTACK AGAINST SACRIFICIAL HIMSA AND OBLATION TO DEITIES

[Sacrifices in Olden India and their condemnation, the True Sacrifice, story of Parvata and Nārada, determination of the *gati*, *homa*, and oblations to Deities].

Every rule has an exception. The general rule such as "no living being should be killed or injured" has an exception, in case this *hiṃsā* is enjoined by the *Vedas*. This view, though, not much supported now-a-days, was once strongly held and defended by a religious school in India.

Sacrifices in olden India and their condemnation.—That horses, bulls and even human beings were killed for sacrificial purposes in olden India is a fact which needs no proof. So it will suffice to refer to *Aitareya Brāhmaṇa* (IV) only. That even, at a very early period of our history this practice was condemned by some of the *Āidikas*, is also borne out by this very *Brāhmaṇa*. Further, that vegetables which were substituted for animal offerings were regarded as characteristic of 'kṣātra-yajña', is also supported by various works such as MBh (Śānti-parvan, Nārāyaṇīya section). This shows that there was a sharp difference of opinion regarding the animal slaughter and meat-eating permitted or prescribed in certain cases such as a sacrifice, certain *śrāddhas*, reception of learned guests, etc. That the *Pūrva-Mīmāṃsikas* were for this practice while the *Sāṃkhayas*, the *Jainas*, and the *Bauddhas* denounced them is

¹⁰⁰ This is referred to in Bambhadattacarīya, a narrative occurring in the commentary (pp. 185b—197b) on *Uttarajñhayāṇa* (XIII) composed by Nemicaṇḍra in *Saṃvat* 1120.

¹⁰¹ Vide *The Spectator* No. 6137 dated 8-2-46.

borne out by their literatures.¹⁰² Turning to the *Jaina* literature we find that *Syādvādamañjarī* composed by Malliṣena in Śaka year 1214 i.e. 1298 A.D. furnishes us and deals with this topic in a comprehensive way. Dr. A. B. Dhruva in his Notes on SM observes on p. 338 :—

"The texts of Śruti, Smṛti, Mahābhārata and Purāṇas, as well as the views of Sāṃkhya, Vedānta and Bhakti schools of religion cited in the *Syādvādamañjarī* and in the extracts given above leave no doubt that there was a strong body of opinion even in Brahminism which revolted against *hiṃsā*, even *Vaidhahīṃsā* (i. e. *hiṃsā* prescribed in Śāstras, such as animal slaughter in sacrifice). This trend of thought seems to have come down from times earlier than the rise of Jainism and Buddhism, mainly in the Bhakti and the Jñāna schools distinguished from the ritualist school of Brahmanism."

The true sacrifice—In *Uttarajjhayana* there is a discussion as to what a true sacrifice is. For instance in XII, 39 and 42-44 it is said :

“कुसं च जूवं तणक्कमग्गि
सायं च पायं उदग्गं फुसन्ता ।
पाणाइं भूयाइं विहेइयन्ता
भुज्जो वि मन्दा ! पकरह पावं ॥ ३९ ॥ ”
“सुसंलुब्धा पञ्चाहिं संवेरेहि
इह जीवियं अणवक्कइखमाणा ।
वासट्ठकाया सुइचतदेहा
महाजयं जयइं जन्नसिं ॥ ४२ ॥
के ते जेइ ? के व ते जेइठाणा ?
का ते सुया ? किं व ते कारिसइं ? ।
एहा य ते कयरा सन्ति भिक्खु !
कयरेण होमेण हुणासि जेइ ? ॥ ४३ ॥
तवो जेइ जीवो जेइठाणं
जोगा सुया सरारं कारिसइं ।
कम्मं एहा सज्जमजोग सन्ता
होमं हुणासि इसिणं पसंथं ॥ ४४ ॥ ”

¹⁰² Prof. Dhruva in his Supplementary Notes (p. 238) to S.M. says:—

"A few texts bearing on the subject of *ahiṃsā* will also be found in *Mathara-ṛtti* on the *Sāṃkhya Kārikā*. For a fairly long list of texts bearing on *ahiṃsā* and *yajna* and translated in the various vols. of the "Sacred Books of the East" see "*Ahiṃsā*" in (a) *Jaina* religion, (b) in *Buddhism* and (c) in *Brahmanism* on pp. 30-32 and "Sacrifice—(d) Relative value or worthlessness of sacrifice, and symbolical sacrifice on pp. 482-83 in Winternitz "Concise Dictionary of Eastern Religion."

The pertinent volumes and their pages for (a) are:—

Vol. XXII, 31 ; XXII, 36 ; 38sq. ; XLV 247 sq., 248n, 311 ; XXII 30-32, 63sq. ; XLV, 25, 33sq., 251sq., 254, 259, 271, 295, 311, 351, 404sq. ; XXII, 202-4 ; XLV 260, 290, 306sq., 314, 329, 379, 377, 386sq. ; XXII, 3-14, 62, 42 ; XLV, 236, 259, 21, 279, 286, XXII 47, 47n., 72, 75, 97, 100, 120, 126, 128, 132, 136sq., 139, 145, 161sq., 169sq., 178-83, 304-8 ; XLV, 129, 135sq., 146sq., 11, 145 ; 145n, 204sq., 10, 10n, 255, 255n, XXII, 103sq., 117, 7sq., 67, 67n ; XLV 293, 358 ; XXII 88sq., 104-110, 81 ; XLV 17sq. ; XXII 12, 18 ; XLV 55, 78sq., 114, 418sq., 421-33, 421n., 312sq., 357-60.

A most interesting and instructive treatment of the subject with a long list of quotations made from the MBh and the *Purāṇa* and the *Smṛtis* will be found in the edition of the *Sāṃkhya Kārikā* with *Sāṃkhya-Tattvakaumudī* annotated by Balarāma Udāsina of Benares.

These mean: Oh dull-witted ones! You once more commit sin by harrassing *prāṇas* and *bhūtas* when you touch in the evening and in the morning *kuśa*, a sacrificial post, grass, wood, fire and water (39).

Those who are well-restrained by the five *saṃvaras*, who do not crave for life in this world, who have given up (attachment to their body) perform the best sacrifice which is highly victorious (42).

What is your flame? What is your place for a flame? What are your ladders? What is your dried cow-dung? Oh monk! Which is your fuel? What is your *śānti* (i.e. rite for averting evil)? And what oblation do you offer by the flame? (43).

Penance is my flame. The living being is the place of my flame. Activities are ladders. The body is a dried cow-dung. *Karmans* are the fuel. Activities surcharged with self-control is *śānti*. And I offer praise-worthy oblation to sages. (44).

Story of Parvata & Nārada—In *Vasudevahiṇḍī* (pt. I, p. 189) we have: Once when Parvata was explaining to his pupils the meaning of the word 'aja', Nārada, his co-student, happened to go there. Parvata rendered 'aja' as 'goat'. Nārada corrected him by saying that their preceptor Kṣīrakadambaka had taught its meaning as 'corn three years old'. Not only did Parvata not agree to it, but he bet that whoever was proved to be wrong should have his tongue cut off. Thereafter Parvata and Nārada went to their co-student Vasu, a king.

In the meanwhile when the mother of Parvata came to know about this she was grieved. She said to her son that his father had explained 'aja' just as Nārada had said, and he had committed a great blunder in betting. Parvata said that he was not prepared to withdraw his word. This caused extreme anxiety to her. In order to save her son she went to Vasu. He said that as Nārada was right he could not give a verdict in favour of Parvata. Then this lady got exasperated and argued with Vasu; but as he did not yield she left him in despair. Thereafter Nārada and Parvata went to the royal court, and Vasu sided with Parvata. Gods got enraged at this, and they immediately destroyed the crystal throne of Vasu which was giving a false appearance to the spectators that Vasu was seated without any support.

Determination of the gati—Once when this very Upādhyāya, Kṣīrakadambaka by name, was teaching his own son Parvata along with Vasu (a prince) and Nārada, a Brāhmaṇa, two *cāraṇa-munis* happened to pass by his house. On seeing these three pupils they said: One of them will have a good grade of existence (*sad-gati*) and the other two a bad one (*dur-gati*). On hearing these words Kṣīrakadambaka became anxious to find out as to who was going to have a *sad-gati*. He thereupon prepared three cocks out of flour and gave one to each of his pupils with the instruction that they should kill their cock in a place not seen by anybody. Vasu went to a dark cave, and there he killed his cock. Parvata did so by remaining hidden behind a fence of a field. Nārada went to a forest, and he was about to kill his cock when an idea struck him that though there was none there, at least he and God did see what he was about to do.

As there was no such place which was hidden from him and God, he went back with his cock and explained to his preceptor why he did not kill it.

Vasu and Parvata narrated to the preceptor what they had done. This made the preceptor infer that Nārada was to have a *sad-gati* whereas the remaining two *dur-gati*.

Homa—From *Vivāgasūya* (I, V) we learn that a king Jiyasattu (Sk. Jītaśatru) had a Brāhmaṇa purohita Mahesavadatta (Sk. Maheśvara-datta) by name. He was well-versed in the four *Vedas*, etc. In order to enhance the kingdom and power of this king he caused every morning a boy from each of the four castes, viz. *Brāhmaṇa*, *Kṣatriya*, *Vaiśya* and *Śūdra*, to be seized and their heart-balls extracted alive with which he performed *śānti-homa* i.e. *homa* sacrifices to propitiate gods on behalf of the king. On the eight and the fourteenth days (of every fortnight) he did so, but the number of boys from each caste was two. Every four months he performed *śānti-homa* with four boys of each caste, with eight each every six months, and with sixteen each every year. Whenever king Jiyasattu was attacked by an enemy, Mahesavadatta caused 800 boys of each caste to be seized, and he performed *śānti-homa* with their heart-balls extracted alive. Thereupon the enemy's army was either immediately destroyed or checked.

This shows that offering of human sacrifices on the eve of important undertakings was in vogue at one time in India.

Oblations to deities—Some persons offer a human being or a beast to a deity as an oblation with a view to warding off an evil or to fulfilling the vow undertaken when some desired goal is to be achieved. Hemacandra in his *Yogaśāstra* (II, 39) says: those cruel persons who kill animals under the guise of an oblation to a deity or a sacrifice, attain a bad grade of existence. In its com. he explains 'deity' as Bhairava, Caṇḍikā and others.

A human oblation to Kaccāyaṇī (Sk. Kātyāyaṇī) is twice referred to in *Samarāñcacarīya* where on pp. 530-532 a beautiful description of a temple of caṇḍiyā (sk. caṇḍikā) is given—the description which may remind one of Vindhyaśini given in *Gaṇḍhavaḥa* (pp. 285-338).

NĀGAVARMA AND JAYAKĪRTI ON KANNADA METRES

BY K. G. KUNDANGAR

CHANDŌMBUDHI the only earliest work on prosody that has come down to our hands is of Nāgavarma of 990 A. D. The author refers in it to Piṅgala, Jayadeva and Akṣaradhavala. In this book he treats at length Samavṛttas, Mālāvṛttas, Ardhasamavṛttas, Viṣamavṛttas, Ragales (Raghaṭā, also called Paddhati and Pajjhaṭikā in Sanskr̥ta and Prākṛta respectively), Mātrāvṛttas, and Karnāṭaka-*viṣaya-jāti* (Tripadi, Akkara—Akṣara in Sanskr̥ta—, Eḷe—Eḷā in Sanskr̥ta—, Akkarike—Akṣarikā, Caupadi, and Ṣaṭpadi). Of these some Mālāvṛttas, Raghaṭās, Mātrāvṛttas, and Karnāṭaka—*viṣaya-jāti* have been treated by Jayakīrti in his Chandōnuśāsana which has been partially published recently by Prof. H. D. Velankar in Journal of the Bombay Branch Royal Asiatic Society N. S. Vol. 21, 1945. This has afforded an opportunity to compare here the Vṛttas as they occur in both these works.

Samavṛttas need not be touched as they are common to both Sanskr̥ta and Kannada except *Uṭpalamāla* and *Caṃpakamālā* which are not of common occurrence in Sanskr̥ta literature. Their definitions are :

उत्पलमालैयप्पुदु भरनभभरलगं नेगळिदरल् ॥

Its scheme will be :

- UU | - U - | UUU | - UU | - UU | - U - | U -

नजभजजंजरं वगेगेळुत्तिरे चंपकमालैयेदंपर ॥

Its scheme will be :

UUU | U-U | -UU | U-U | U-U | U-U | -U -

In the Mālāvṛttas Nāgavarma refers to the only two vṛttas—Lalita and Kusumarasa. Lalita is also called Lalitupada. The definition given by him runs thus :

Lalita has भजनभजनमय gaṇas¹ with Yatis at the 8th and 16th syllables.

¹ ताने शशिसूर्यपवमानसुरातकरभानुमरुदिद्रविधुतोयदे विराम ।
स्थानमेसेयु पदवितानदोल्लुक्कमदे नीनरिबुदीललितवृत्तमनिदं चंद्रानने ॥ २०४ ॥

मगण—भूमि

तगण—अंबर

यगण—जल

जगण—सूर्य

रगण—अग्नि

भगण—शशि

सगण—वायु

नगण—नाक

Lalita is also included in Mātrā-gaṇa-vṛttas under the name Laya-grāhi. It is a vṛtta of four lines and contains seven gaṇas of 5 mātrās and one of four.¹ Dr. Kittel differs from this view. He says that each line contains 7 gaṇas of five mātrās and two gurus, and yati at every 8th syllable. According to this the scheme will be :

—UUU | —UUU* | —UUU | —UUU* | —UUU | —UUU* | —UUU | —||

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This variety closely resembles Kusuma-ṣaṭpadi.

The next Mālāvṛtta described is Kusumarasa of 31 syllables and is defined and illustrated by the same verse.² It has नननननननननजसग gaṇas and caesuras at the 10th and 20th syllables.

Of these two Lalita has been traced in Kannaḍa poetical works while Kusumarasa is not met with so far.

Acyuta, Kalpalate and Raviprabhe are the three Ardhasama vṛttas to be found in N's Chandōmbudhi.

In the Acyuta, the lines of Sumukhi and Citrapada are used alternately. The scheme of the vṛtta therefore will be :

नजजलग ।

भभभग ॥

नजजलग ।

भभभग ॥

Similarly Kalpalate is formed of Rathōddhata and Nirupama lines. The scheme will be :³

रनरलग ।

नभजर ॥

रनरलग ।

नभजर ॥

¹ Kannaḍa-kaipidi, p. 113.

The following line is an illustration from Kittel :

धीरजनरि श्रुतविचारपररि लसदुदारगुणरि दुरितदूरनिजभक्त्याचारयुतरि ...॥ 276 ॥

² सुरर पडे नेरे दिरलु करिगेळें नितनितरोळें खरकरसमीरणपदांतं ।
पुरमथननिदे बळिक नेरे दु यति दशमेदोळें तरतरदि नोप्पि निळें संतं ॥
धेरयोळिदु नेगळव कविवरमतदि जननुतादि परमपदेवेंदिदुदनंतं ।
सरसिरुह-दळनयेन करमेसेव कुसुमरस निरतिशये मँबुदु नितान्तम् ॥ 205 ॥

³ पावकामरगणानळं लगं ।

दिविजचंद्र कुमुदारिपावकं ॥

भाविषुतुमिरे कामलोक्तिसं- ।

भविसे कल्पलतेयायु नामदिम् ॥ २०८ ॥

Raviprabhe is formed of lines of two vṛttas of 20 and 18 syllables and its scheme will be :¹

नजजजजलग ।
भभभभरन ॥
नजजजजलग ।
भभभभरन ॥

It will not be out of place to illustrate here an instance of Ardha-samavṛtta occurring in Gadāyuddha of Ranna (993 A. D.). It is formed of Maṭṭabhavikṛīḍita and Mahā-sragdharā lines used alternately.

इरलीमाद्रितनूजरिबंरवरिन्नेगेदपधर्मजं ।
बेरसीगळ् भीमसेनं पौणरलिनिबर्गं नंदनम् मूर्वरल्लो ॥
नरनुं बर्के कृतांतजं पवनजं गांडीवधानुष्कम् ।
वरोळोर्व बर्के भीमं तोडर्दनिबोळं बर्के मेण बन्नमीवेम् ॥ ७-४१ ॥

Nāgavarma defines Ardhasamavṛtta :

“When a metre is formed with changes in lines by adding or removing some syllables it is called Ardhasamavṛtta. I explained to you clearly, oh lotus-faced one.” This definition gives a clue to understand the fact how poets were indulging in forming new Ardha-sama-vṛttas of their own. But the fact that Ranna has not named it is itself a proof of its new formation.

In the Viśama-vṛtta section Nāgavarma mentions Udgata, Tripadōnnati and Pada-caturūrdhva. In addition to these Jayakīrti gives Saurabhaka, Lalita and Kīrti. He does not mention Tripadōnnati. All these are described in IV Chapter of Chandōnuśāsana. Nāgavarma's definitions of the three Viśama-vṛttas are given here with a belief that they will be useful for comparison when the whole of Chandōnuśāsana of Jayakīrti is published by Prof. Velankar.

Udgata :

सजसल ।
नसजभ ॥
भनजलग ।
सजसजग ॥²

¹ अमरसरोरुहमित्रगणोदधिसंख्ये चंद्रहरं ।
सोमगणंगळे नालेकडेयोळबरे पावकं मरुतं ॥
क्रमदेळि बंदनुलोमंदोळोदि पदद्वयं निरुतं ।
नेममिदके रविप्रभमागळे वेळकुमब्जमुखी ॥ २०९

² मरुदकं वायु लघु सुदे ।
बरे सुरमरुद्दिनेशगं ॥
वारिजरिपुसुरपार्कलगं ।
मरुदकं वायुरविशीशनुद्गतम् ॥ २१२ ॥

Tripadōnnati :

भभभग ।
भभभग ॥
भभभभ ।
भभभग ॥ ¹

Padacaturūrdhvam :

नयगग ।
सभजम ।
ननसजयग ।
स्रजतयरजलग ॥ ²

Mention is made of two Kannaḍa vṛttas Duvayi (Dvipadi) and Utsāha or Utsava in Chapter VI of Jayakīrti's Chandōnuśāsana.

Duvayi :

Duvayi has two lines. The first gaṇa of these two lines is to contain six mātrās. The other gaṇas must contain four as in Kaṇḍa (Skandha) and the sixth is to be a Jagāṇa.³ Each line is to contain 28 mātrās. This definition tallies with that of Jayakīrti.

Utsāha or Utsava :

This vṛtta belongs to Kaṇḍāka-viśaya-jāti according to Nāgavarma. It is therefore necessary to understand the nomenclature of the Gaṇas mentioned by the two authors Nāgavarma and Jayakīrti. Following is the table giving necessary information of the Gaṇas according to both the authors.

-
- ¹ चंद्रगणत्रितयं केडेयोळ ।
चंद्रधरं बरं मूरं डेयोळ ॥
चंद्रचतुष्टयमागिरे भाविसु
चंद्रमुखी त्रिपदोन्नतियम् ॥ २१४ ॥
- ² अतिशय-वाक्संपन्नं ।
शतपत्रोद्भवमहान्वयोत्पन्नं ॥
चतुरकविकुलललामं लसद्गुणोद्दामं ।
चतुराननं द्रमं त्रिप्रतिमं श्रीनागवर्मनप्रतिमम् ॥ २१६ ॥
- ³ मोदलेळे मात्रेगळार ।
पुडु पदवेरं डेरोंळमते कंदद गणमे ॥
पुदुयिसि गुरुवेरंसिकं ।
त्यदिनिर्पत्ते मात्रे दुवयिगे नियमम् ॥ २१६ ॥

Gaṇa-prastāra	Nāgavarma's name	J. K.'s Name	J. K.'s short sign	Varieties
—	Brahma	Rati	Ra	4
—	Viṣṇu	Madana	La	8
—	Rudra	Śara	Dha	16

(For the details of these gaṇas please refer to J. U. Bombay, Vol. IX, Part 2, September 1940, p. 171).

Utsāha :

In this vṛtta occur 7 Aja-gaṇas (with 3 mātrās) with a long syllable at the end and sweet sounding letters.¹ In this definition both of our authors agree.

Mahōtsava of Jayakirti cannot have a place in Karnāṭaka-viṣaya-jāti inasmuch as it contains a Jagana (U—U).

Layōttara :

Layōttara-vṛtta occurs in Nemicandra's Līlāvatī.² Its definition though not given by Nāgavarma may be deduced very easily. Each of its lines contains 14 gaṇas of 3 syllables and one of 5 at the end.

The VII chapter of Chandōnuśāsana is completely devoted to Karnāṭaka-viṣaya-jāti of which Tripadi is the first metre. There seems to be a little confusion in the opinion of Jayakirti when he appears to opine that "the three kinds of Tripadi are Cītrā, Vicitrā and Elā." For, Nāgavarma clearly differentiates Tripadi from Cītrā, Vicitrā and Elā and defines it independently.

Tripadi :

The first line contains 4 gaṇas of 5 mātrās each with a caesura at the end of the second gaṇa, an ādiprāsa in the third gaṇa. The VI and X are to be Brahma-gaṇas.³ Jayakirti's definition agrees with this.

¹ भूहितार्थमे निधुवजन गणमेव बरे सप्रसं ।

दोहमतले दे गुरु बेडंगनाळदु निले लग्न ॥

प्रादियागि मधुरवचनरचने वेत्तु बेदोड्ड ।

त्साहमे ब पेसरो ले से बुदजपत्रलोचने ॥ २५७ ॥

² तुरगे तुंविगुहळ बंबलिदे कपोलरंगदोळ तुळुकं पेंगरंगदोळ मलंगे विजयमंगदोळ ।

मिरुगे पळ चविगळा लेदु ने लु यानदोळ बेडंगु बेळये मानदोळ मनं तोडे के दानदोळ ॥

³ बिसरुहोद्धवगणं रसदशस्थानदोळ ।

बिसरुहेनत्रगणमे बकुळिदुलु ।

बिसरुहेनत्रे त्रिपदिगे ॥ २४८ ॥

The scheme of the metre will be :

UUU— | UUU— | UUU— | —U— |
UUU— | —VI— | UUU— | UUUU |
UUUU | —X— | UUU— ||

✓ This metre is noticed in an inscription of about 700 A. D. at Bādāmi. Later on it became very popular with the Virāṣaivas. Tripadi, when recited in a particular way, gives rise to a new metre called Sāṅgatyā. In reciting, stop at the end of the III gaṇa of the second line and repeat the whole line once again as a third line of the verse. Finally recite the natural third line. This makes the metre to contain four lines and is called Sāṅgatyā. (Compare Ghattā-ṣaṭpadi as defined in Kavi-darpaṇa.)

सालवनु कौवाग हालोगरुंडेत ।

सालिगरु बंदु ऐळे वाग किचबदिय । कीलु मुरिदै ते सर्वज्ञ ॥

This verse may be recited as, and is recited now as :

सालवनु कौवाग हालोगरुंडेत ।

सालिगरु बंदु ऐळे वाग ॥

सालिगरु बंदु ऐळे वाग किचबदिय ।

कीलु मुरिदै ते सर्वज्ञ ॥

But in Sāṅgatyā the repetition of the second line is avoided and in its place a new line is formed to give a vṛtta of four lines. E.g.

तूगी रे रंगन्न । तूगी रे कृष्णन्न ।

तूगी रे अच्युतनंतन ॥

तूगी रे वरगिरियप्प तिम्मप्पन ।

तूगी रे कावेरिरंगन ॥ ध्रु ॥

This Sāṅgatyā metre was of a later development and was first used by Śiśumāyaṇa in his Añjanācarite about 1233 A. D.

Citram :

This has a Rudraṇa at the beginning, Brahma-gaṇas at the VI and X places and Viṣṇu-gaṇas at the remaining places.¹ The scheme will then be :

UUU-U	|	UUU-	|	UU-U	|	UUUU	|
UUUU	|	UU VI-	|	UUUU	|	UUU-	|
UUUU	|	-X U	|	UU-	|	-||	

This definition does not agree with that of Jayakīrti. He says that all the gaṇas are of the Madana (Viṣṇu) type except the VI and X which are to be of the Rati (Brahma) type and VII and XI ones are to begin with two short letters ; whereas Nāgavarma wants the I to be a Rudraṇa. He does not say anything about the VII and XI gaṇas.

Citralatike or Vicīṭra or Citralate :

If Citrā contains a Rudraṇa at the end of the third line it is Citralatike.² Jayakīrti agrees with this definition in the formation of the last

¹ भुजगपक्षगतिशिखिजपदगणदोळ ।

गजरसदसदोळ् पेरै बॅडै योळगधो- ।

क्षजगणसोदोळदु चित्रम् ॥२४९॥

² तुदियोळ्गीश्वरगणमोदवि रे पदमेळ् ।

मदगजगमने पेरगण चित्रदं ।

दोळ्दोळैदं चित्रलतेयकुम् ॥२५०॥

gaṇa. The rest he says is to be like Citrā. According to Nāgavarma the scheme will be :

UUUU— | UUUU | UUUU | UU— |
 UUUU | UU VI | UUUU | —U— |
 UU—U | UU X— | UU—— ||

Elē—Elā of Jayakirti.

The definition of Elē given by Nāgavarma cannot be properly construed as it is full of spelling mistakes. The different readings also cannot solve our difficulty for the same reason. In the definition Nāgavarma appears to opine that there must be three Rudra-gaṇas and the VI is to be an Aja-gaṇa.¹ This does not agree with the illustration. The scheme according to the illustration will be :

UU—U | UU— |
 UU— | UU—U |
 UU—U | UU VI— ||

A second reading of the third line मज्जणे भवती gives the required Brahma-gaṇa.

UU—U | UU VI— ||

Jayakirti's definition of this metre is worth noting. The Elā contains the first two pādās of two gaṇas each and the last pāda of three gaṇas out of the four pādās of a Tripadi. Thus the rule about the sixth and the seventh gaṇas is inoperative in the case of the Elā Tripadi as it does not contain them.

Akṣara-vṛttas, Akkara of Nāgavarma, are completely forgotten now. The names of five Akkaravṛttas are mentioned in Jayakirti's Chandōnuśāsana in Sanskr̥ta and Appakavi in Telugu. Their names are given in the following table :

No.	Nāga's Name and Gaṇas	Jayakirti's Name and Gaṇas	Appakavi's Name and Gaṇas	No. of Gaṇas
1	Kiriyakkara 2 Vi. 1 Ru.	Alpākṣara 2 Madana 1 Śara	Alpākara 2 Indra 1 Candra	3
2	Edeyakkara 1 Br. 2 Vi. 1 Ru.	Antarākṣara 1 Rati 2 Madanas 1 Śara	Antarākara 1 Surya 2 Indra 1 Candra	4
3	Naḍuvaṇakkara 1 Bra. 3 Vi. 1 Ru.	Madhyamākṣara 1 Rati, 3 Madana 1 Śara	Madhurākara 1 Surya 3 Indra 1 Candra	5
4	Doreyakkara 2 Vi. 1 Bra. 2 Vi. 1 Bra.	Samānākṣara 2 Madana 1 Rati 2 Madana 1 Rati	Madhyākara	6
5	Piriyakkara 1 Bra. 5 Vi. 1 Ru.	Mahākṣara 1 Rati 5 Madana 1 Śara ; or 2 Ra. 1 Ma. 1 Ra. 2 Ma. 1 Śa. ; or 6 Ma. 1 Śa.	Mahākara 1 Surya 5 Indra 1 Candra	7

¹ भुजगपक्षपुरगण ।

ब्रजदोळारोळकु- ।

मज्जणे ळभिभगती ॥२५१॥

Madhyākkara and Madhurākkara, the Telugu equivalents of Doreyakkara and Naḍuvaṇakkara of Nāgavarma do not carry the exact sense, while Jayakirti's Samānākṣara and Madhyamākṣara convey it properly.

Nāgavarma does not recommend yati to any of the Akṣaravṛttas while Jayakirti recommends that there should be a yati at the end of every gaṇa in all the varieties of the Akṣara. Appakavi prescribes a yati at the end of the 4th gaṇa in Piriyaṅkara, at the end of the 3rd in Doreyakkara and Naḍuvaṇakkara, and at the end of the 2nd in Eḍeyakkara and Kiriyaṅkara.

Piriyaṅkara is the only metre which has come down to us. Nāgavarma defines it :

In each line of this metre the first gaṇa is necessarily to be a Brahma-gaṇa, then there are to be five Viṣṇu-gaṇas and at the end there is to be a Kandarpa-ripu (Rudra) gaṇa. In second and fourth lines the sixth is to be a Brahma¹-gaṇa. According to this the scheme will be :

UUU	|	UUU—	|	—UU	|	—U	|	—UU	|	—UU	|	—U—	|
UUU	|	—U—	|	UU—U	|	—	|	UUUU	|	—VI—	|	UUU—U	||
UUU	|	UU—U	|	—UU	|	—UU	|	UU—U	|	—U—	|	—U—	|
UUU	|	—UU	|	—UU	|	—UU	|	—UU	|	VI	|	UU—UU	||

It appears poets have not strictly observed this rule. Sometimes a Viṣṇugaṇa is replaced by a Brahma-gaṇa and in 2nd and 4th line the Brahmagaṇa does not find its proper place. This irregularity is noticed in Bhārata and Ādi-purāṇa of Pāṃpa. Vide Kannaḍa-Kaipīḍi pp. 152-156.

Doreyakkara is Samānākṣara of Jayakirti. Nāgavarma's definition is :

"This metre contains six gaṇas. Two Viṣṇu-gaṇas and a Brahma-gaṇa are to be at the beginning and two Viṣṇu-gaṇas and a Brahma-gaṇa are to be contained regularly at the end of each line."²

The scheme will be :

UUU—	|	UUUU	|	UUU	|	UU—U	|	UU—U	|	—	|
UUU—	|	UUUU	|	UUU	|	UU—U	|	UUU—	|	—	|
UUUU	|	—U—	|	UU—	|	UUU—	|	UU—U	|	UU—	||
UU—U	|	—UU	|	UU—	|	UUUU	|	UUU—	|	UU—	||

- ¹ मोदलोळजगण कुंददे बर्कतमय्दुगणंगळे विष्णुवक्कुं ।
 लुदियोळे ब ताणदोळे लिंयुं कंदर्परीपुगणं तां नेलसि नित्के ॥
 पददोळे रडे ब संखेयोल्लारेल्लजगणं समवायमणोडकुं ।
 स्रदमळेंदुनिमानने नाकिगनिष्टदिनितिदु पिरियक्करम् ॥ २४२ ॥

In the fourth line the VI gaṇa is not the prescribed Brahma but a Viṣṇu. Dr. Kiteļ gives a second reading कर्तृविनिष्टदिनरिदु पिरियक्करम् which rightly supplies the required Brahmagaṇa,

- ² सरसिजोदरगणमैरडजनुमल्लि नेरेदिके मत्रं ।
 सरसिजोदरगणमुमैरडजनके गणमुमारकुं ॥
 सरसिजलोचने दोरे वेत्र गणदि दोरे वेत्र पेसरि ।
 दोरे यागि संदुदु दोरे यक्करमिदनरिदु तेरदिम् ॥ २४३ ॥

Jayakīrti points out that this metre has been used by Asaga in his Kannada Kumāra-saṁbhava-kāvya. An Asaga is mentioned in Karnāṭaka-Kavīcarite Vol. I p. 39. The date ascribed to him is 945. But no Kannada work of Asaga is traced, though two Sanskrit works of his have come to light.¹ Examples of this metre are not found in Kannada.

Naḍuvaṇakkara is Jayakīrti's Madhyamākṣara. Nāgavarma's definition is :

"This metre contains five gaṇas only. It is to contain a Brahma-gaṇa at the beginning, three Viṣṇu-gaṇas in the middle and a Kāmāntaka (Rudra) gaṇa at the end like a row of the five arrows of Kāma."²

The scheme will be :

000	|	- 00	|	00 - 0	|	0000	|	000 - 0	|
000	|	--00	|	00--0	|	--0	|	00--0	|
000	|	--00	|	0000	|	-0	|	-0--	|
000	|	--0	|	00-0	|	000-	|	0000-	||

As illustrations of this metre Jayakīrti points to Kannada Mālatī-Mādhava-kāvya. This is the first reference to a work of that name, so far as we know.

Eḍeyakkara is Jayakīrti's Antarākṣara. Nāgavarma's definition of it is:

"A Brahma, two Viṣṇu and a Rudra-gaṇa occur in each line of this metre, and each line contains only four gaṇas."³ He does not make mention of yati in his definition.

The scheme will be :

000	|	-00	|	00-0	|	000-0	|
000	|	-00	|	0000	|	00-0-	||
000	|	-00	|	-00	|	0000	|
000	|	000-	|	00-0	|	-00-	||

It is well known from the Karnāṭcāvara-kathā and other Jain poems, says Jayakīrti. These works also have not come down to us.

Kiriyakkara is Jayakīrti's Alpākṣara. Nāgavarma's definition of it is:

"This metre contains only three gaṇas. There will be two Viṣṇu-gaṇas at the beginning of each line and a rudra-gaṇa at the end."⁴ He does not mention yati. This definition tallies with that of Jayakīrti.

¹ Asaga, his works and date, The Karnāṭaka Historical Quarterly, Vol. II, i, pp. 42-47.

² ಜಲಜಸಂಭವಗಣಮಕ್ಕೊ ಮೊದಲೊಂ ನಡುವೆ ಮೂರು ।

ಜಲಹೊದರಗಣಮಕ್ಕೊ ಕಾಮಾಂತಕಗಣ ಬಹು ॥

ತಿಲಕದತ್ತಿರ ತಲೆಯೊಂ ಬದಿಕೆ ಕಾಮವಾಣಿ ।

ವಿಜಯ ಪಾಂಗಯೆದ ಗಣಮಕ್ಕೊ ನಡುವಣಕ್ಕೊ ಸಖಾ ॥ ೨೪೪ ॥

³ ವನಜಸಂಭವಗಣಮಕ್ಕೊ ಮೊದಲೊಂ ತಲೆ ।

ವನಹೊದರಗಣಯುಗಲಗದಕ್ಕೊ ಸು- ॥

ಬ್ರಹ್ಮದತ್ತದೊಂ ಬದಿಕೆ ನಾಲಕೆ ಗಣ- ।

ವನಿತೆ ವನಿತೆ ಕೆಲೆಡೆ ಯಕ್ಕರಕ್ಕೊ ನಸುಮ್ ॥ ೨೪೫ ॥

⁴ ಪೊಡೆ ಯಲರವಿರವೊಂ ದಲೊಂ ಕೆಂ ।

ಜಡೆಯ ಶಂಕರನೊಂ ವಿದಿಯೊಂ ಕೆಂ ॥

ಮಡದಿ ಕೆಲಮೂರೆ ಗಣಮೆ ಸೆ ದಿಕೆಂ ।

ಗಡ ಕಿರಿಯಕ್ಕರಕ್ಕೊ ಲಕ್ಷಗಮ್ ॥ ೨೪೬ ॥

The scheme will be :

UUUU	| UU--	| UUU--U	|
UUU--	| UU--	| UUU--U	|
UUU--	| --U	| UUU--U	|
UUUU	| -U--	| UU--U--	||

It is well known in the Kannaḍa poems like Sṛṅgāra-piṇḍa-kāvya says Jayakīrti. This work also has not come down to us.

Caupadi is Jayakīrti's Catuspadikā.

Each line contains a Viṣṇu-gaṇa at the beginning and a Śaṅkara—(Rudra)—gaṇa at the end.¹ According to this definition the scheme will be :

UUUU	| --UU--	|
UUUU	--UU--	
UUUU	--UU--	
UUUU	--UUU	

Chandōvataṁsa is Jayakīrti's Chandōvataṁsa or Ādivarāha. Nāgavarma says "Each line of this metre contains a Viṣṇu-gaṇa at the beginning and then four Brahma-gaṇas."² Jayakīrti agrees with this definition. The scheme of the metre will be :

--UU	| UUU	| UUU	| UUU	| UUU
--UU		| UUU	| UUU	
--UU	--U	| UUU	| UU--	UU--
--UU	--	| UUU	| UUU	UU--

Akkarīke is Jayakīrti's Akṣarikā. Jayakīrti agrees with Nāgavarma in his definition. According to Nāgavarma each line contains Viṣṇu, Brahma, Viṣṇu, Brahma, Viṣṇu and Rudra gaṇas in succession and yati occurs at every sixth syllable.³ Jayakīrti seems to prescribe further restrictions for the metre. According to Nāgavarma the scheme will be very simple and is illustrated by one line only at the foot note.

Madanavati is the same in Jayakīrti's work. He (Jayakīrti) appears to have word fighting in the definition of this metre. He says "Every line must contain 22 mātrās only irrespective of the number of letters which it may contain ; but the last line must have 20 short letters followed by a long one, while the other lines must each have four Madanas followed by one Rati. In no case, however, is the rule of 22 mātrās in a line to be violated ; consequently the 4 Madanas together must not contain more than 18 mātrās, the last 4 being required by the Rati." But Nāgavarma gives three different forms of it in his definition. In the first variety there occur 5 Viṣṇu-gaṇas followed by a guru at the end.⁴ According to this the scheme will be :

UUUU	--UU	UUUU	UUUU	UUUU	--
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¹ मदनन तंदेय मुं । दुदयिसे शंकरनो ॥

ळोदविरे संदुदु नो । डिदे सति चौपदिगे ॥ २५२ ॥

² मंदरधरणमे से दिरे मोदळेळे । बंदिरुं नालकेडे बिसरुहजम्मम् ॥

संदुदु लक्ष्मणमवनियोळी ते रदि । छंदेवतंसके से दुदु गजगमने ॥ २५३ ॥

³ मुररिपुबोम्मं मुररिपुबोम्मं मुररिपुश्लधरं ॥ २५४ ॥

⁴ मदनन तंदेय गणमवु विषयदोळिरे गुरु मुं ।

दोदविरे पददोळमदर वोळपुदु हरपदमुं ॥

विदितमुपेवचतुष्टयस्तलबुजवदने ।

मदनहरत्रयदि हरि कडे पडे मदनवती ॥ २५५ ॥

In the second occur 4 Viṣṇu-gaṇas followed by a Rudra-gaṇa. The scheme will be :

UUUU | -UU | UUUU | UUUU | UUUU -

In the third occur three Rudra-gaṇas followed by a Viṣṇu-gaṇa. The scheme will be :

UUUU - | UU-UU | -UUU | UU-
or UUUU - | UUUUU | UUUUU | UUUU -

Gitike is Jayakīrti's Gītikā. He calls it an Ardhasama-catuṣpadi. The definitions of both agree to a great extent. According to Nāgavarma the second and sixth gaṇas of each half are to be Brahma-gaṇas while the others are to be attractive. The second half is to be similar to the first.¹ This definition is defective. For, it does not state any definiteness to the remaining gaṇas. Nāgavarma's scheme is :

UUUU | -- | U-U- |
UU-U | UUUU | UU- | UUUU- ||
UU- | UUU | --U- |
UUU- | -UU | -- | -U- ||

(In the first line there occurs the gaṇa U-U- which has no place in Kārṇāṭaka-ṣiṣaya-jāti. If the reading of the line is corrected as eraḍa-rolārenipeḍeyo!—which is going too much beyond our limits—the scheme will be fairly within the reach of the metre; UUUU | -U | UUU-).

It will not be out of place in this connection to quote an inscriptional evidence of the end of the 10th century wherein all the vṛttas of Kārṇāṭaka-ṣiṣaya-jāti are mentioned as the various ornaments of Sarasvatī²

- ¹ एरडरोळरे ब संख्ये योळ् ।
बरे पद्मभवनुळिदुवु मेळुव ते रदि- ॥
दिरे मुंदण पदं मुनिनं- ।
तिरे करं गीतिके र्थितकुं सखी ॥ २५६ ॥

² The Town-hall Pillar Inscription, Kolhapur, Northern Face. Inscriptions in Northern Kārṇāṭaka and the Kolhapur State, Kolhapur, 1939, pp. 2-3.

- ८सारदादेविगे
९ वे तनेगे गोपांगवागे । गद्यवे तनेगे ग-
१० हिगे योगे । त्रितवे तनेगे कटिकुचप्र-
११ देशवागे । माळत्रितवे तनेगे मकुट-
१२ मण्डळवागे । अंकितेये तनेगे सुळि
१३ कुंतळवागे । छंदवे तनेगदेवे निप
१४ ललाटपट्टवागे । रागंगळ सुळिवुग-
१५ ले तनेगे कुसळ्येळिगळगे । रागंग-
१६ ल कौकुगेले तनेगे कुडुवुर्बुगळ-
१७ गे । नाटिये तनेगे नोटवागे । ...
... ..
२१ वदरचेनेये तनेगे

purporting thereby that these metres were very popular with the Kannaḍa people. But the literary evidence so far collected is not adequate to point out their popularity with the Kannaḍa poets. The reason is not far to seek. Karnaṭaka school of music, also known as South Indian school (Dakṣiṇādi) has greatly contributed to the growth and development of this part of prosody as has been noticed in the case of Ṣaṭpadi. So Nāgavarma is right in defining them in the light of that fine art which has made all his definition in this branch very defective. Now depending as these metres are on Karnaṭaka School of Music they had not, it appears, reached the stage of perfection in Nāgavarma's time. The poets were making experiments on these in their compositions depending entirely on their knowledge of music. This can clearly be seen in Jayakīrti's Chandroṇuśāsana and the poetical works of Paṇṇa, Poona, Nāgavarma, Abhinava-Paṇṇa, Aggaḷa, Ṣaḍkṣaraḍēva and others. Piriya-kara has also been traced in Kannaḍa inscriptions. Candrarāja in his Madana-ti-laka states that the verse "Aṅga-nṛp-āyati-tuṅga-bhujam"¹ is an instance of Eḍeyakkara, Kiriya-kara, Caupadi, two Ṣaṭpadis, Tripadōnnati and other vṛttas, in all 84 varieties. He is a poet of the last quarter of the 11th century. After this period Eḍeyakkara and other Akkara-vṛttas are not noticed in Kannaḍa literature. But the only Ṣaṭpadi which was fully developed at the time of Nāgavarma was Śara-ṣaṭpadi. For, Rāghavāṅka, a very famous poet of the 13th century and Kumudēndu of the third quarter of the same century have been found to have experimented on the forms of the other Ṣaṭpadis. However, Kusuma-ṣaṭpadi has been mentioned by Jayakīrti and Jayadēva has used it in his Gīta-Gōvinda.²

- २२ द्विदुपचनवागे । अंबुवे तनगे वंबु-
- २३ त्रीववागे । पूर्णरागवे तनगे कर्ण-
- २४ भरणवागे । देवाळवे तनगे नेवाळवागे ।
- २५ अकरमे तनगे अरे वाणियागे तिवदि-
- २६ थे तनगे तेळवसिरगे । दोहळमे
- २७ तनगे पाहाबलवागे । चवपदिये त-
- २८ नगे मु...जवागे ।
- २९ रागंगळणुग-
- ३० गवितवे तनगे सेळळुगुर्गवागे ।

¹ अंगनृपायति-तुंगभुजं कलियगितशिक्षितनिदुयशं ।

पिंगजदो गतभृंगकचं कलि मंगळलक्षणयुक्तनिर्वं ॥

संगरकसरि-संगगुणं बलि भृंगरदक्षनुवायुतनुं ।

संगद सन्मति-रंगवहं सले भंगियनीक्षसि माचनुपम् ॥

इदुवे ऐडे यकरमुं, किरियकरमुं, चौपदिकेयुं, ऐरडु षट्टदियुं, त्रिपदान्नतियुं, वल्लमुखियुं,

त्रोटकमुं, चित्रपदकमुं, कमळमुं, चंद्रकेयुं, इंदुमुखियुं मोदलागे ८४ वृत्तमुं, पादमुरज-

बधमुं, गोमूत्रिकेयुमकम् ॥ Kar. K. Ca. Vol. I. pp 93-94.

(This forms an instance of Eḍeyakkara Kiriya-kara, Caupadika, two Ṣaṭpadis, Tripadōnnati, Valjamukhi, Trotaka, Citrapadaka, Kamala, Candrike, Indumukhi, etc., the 84 metres and Pādamurajabandha and Gōmūtrika.)

² J. U. Bom., Vol. VI, Part III, Nov. 1937, pp. 56-59.

LIST OF ABBREVIATIONS USED IN THE ARTICLE

Bra—Brahma.	Ru—Rudra.
J. U. Bom.—Journal of the University of Bombay.	Śa—Śara.
Ma—Madana.	V—Verse.
Ra—Rati.	Vi—Viṣṇu.

ORTHOGRAPHY

Liberty has been taken to use Devanagari script for Kannada.

The absence of \ddot{R} and \ddot{L} in Devanāgarī and consequently their inavailability in printing presses has been made good by the replacement of R . and L in their places respectively.

Dravidian languages have short E and O . These have been represented by \check{E} and \check{O} , and $\check{Ṛ} = dē$, $\check{Ṛ} = dō$.

EMERGENT EVOLUTION AND SAMKHYA PHILOSOPHY*

Part III—C. Lloyd Morgan's Theory of Emergent Evolution

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ADVENT OF EINSTEIN

THE first quarter of the present century has made stupendous progress in the domain of physical sciences. The discovery of the radioactive elements towards the close of the last century threw a flood of light into the darkness of our ignorance regarding the internal structure of gross matter and the behaviour of particles that constitute it. Among the band of pioneers working in this difficult field of material philosophy Niels Bohr, Rutherford, Broglie, Compton, Dumond, Anderson, Bragg and Raman have proved to be the leaders. But with the opening up of this new line of fruitful research, the difficulties in our way of conceiving the matter as made up of atoms were also multiplied. Do the ultimate particles that constitute the matter which is nothing but energy in dynamic equilibrium behave as waves or as particles or as both, something like wavicles, now behaving as quanta of energy and then as corpuscles? Are our concepts of statics in Euclidean geometry based as they are on larger objects, really useful in enabling us to understand the behaviour of the fine particles that go to constitute the matter? Or, is it necessary to form some new concepts appropriate to describe the behaviour of fine ultramicroscopical particles constituting the matter? Considerations such as these led to the formulation of the theorem of Gauss, Plank's constant, relativity of Einstein, indeterminism of Eddington and the principle of uncertainty of Heisenberg. These were clearly the signs of a new orientation in Physics and Mathematics, but the real dawn-breaker of this new era was Professor Albert Einstein whose theory of relativity propounded in 1908 produced as great a sensation as did the "*Origin of Species*" by Darwin in 1859.

Chemistry also had made notable advances in the eighties and nineties of the last century and in the first quarter of the present century by filling up the gaps in the periodic table of Mendeleef formulated in 1876, and by discovering some new inert gases in the air such as crypton and xenon, and by establishing new classes of substances called enzymes, vitamins, viruses and bacteriophages. A growing body of workers in all sciences has been zealously trying to apply the new principles of relativity and uncertainty in interpreting the physical, chemical and biochemical phenomena already discovered and making new discoveries.

* Parts I and II have been published in *Review of Philosophy and Religion*, Vol. 11, pp. 21-35, 1942, and Vol. 12, pp. 56-64, 1943.

Some of them have already gone beyond Einstein and are busy formulating a new geometry of space ; among these C. J. Darwin, Milne and Dingle have attained great prominence. The tendency thus to interpret matter in the old static terms is fast giving way to the new indeterministic way of explanation both in the biological and abiological sciences.

In Biology two great mechanical hypotheses propounded are the laws of Mendel and the germ plasm theory of Weismann. With the recent advances in our knowledge of the behaviour and structure of the chromosomes, particularly in the light of the work of DeVries on the mutations and T. H. Morgan's on the chromosomes of the fruit-fly, *Drosophila*, and the recent work on the gene-mutations by several authors both these hypotheses have undergone considerable modifications, tending more towards the indeterministic way of interpretation. A similar reaction was also noticeable in the domain of evolutionary philosophy the key-word of which has been "Emergence". The idea of emergence, thus has emerged as a kind of revolt against the preformationist tendencies in interpreting the evolutionary processes ; and it is proposed to deal with it mainly in this part. In order to appreciate the full significance of this new idea, it is necessary to understand the preformationist view.

PREFORMATION AND CREATION

When we try to understand the implications of the word evolution we ask ourselves : after all what is evolution ? Is it not unfolding of that which was enfolded before ? Is it not a process whereby *qua implicit* becomes *post hoc* explicit ? Answers to these questions, if we follow the usual way of interpreting the evolutionary phenomena, will have to be given in the affirmative. But such a naive affirmation on our part will immediately open up the dreadful chasm of the much vexed questions in philosophy e.g. the preformation versus epigenesis, determinism versus indeterminism, causation versus causality etc. If the evolutionary process is a mere history of the precedents and antecedents put together in an *ad hoc* manner, as the mechanistic interpretation of the evolutionary process by Darwin and Weismann does in terms of the pruning agency of Natural selection and variations, then evolution amounts to nothing but preformation, a concept quite common in the philosophy of Plato and others. But to a dispassionate seeker after truth, in addition to the preformationist view, two answers suggest themselves : (1) He may admit that the evolution along with the novelties arising in it are the manifestations of some extra-mundane power, or (2) he may accept them as an integral part of reality manifesting itself in evolution with an attitude well expressed by Alexander's famous phrase, natural piety. To most students of science the latter alternative will be preferable. If reality shows novelties from time to time, then it follows that the evolution is not a mere preformative process but also epigenetic. In other words, there is "Emergence" of something genuinely new in the process of evolution as it advances.

"EMERGENCE"

The concept of "Emergence" which is being emphasised now-a-days is meant to show the self-sufficiency of the evolutionary process and is not altogether new. It can be traced back to Lucretius (98 B.C.—55 B.C.) and Plotinus (205 A.D.—270 A.D.), the celebrated stoic and to

many others as shown by Osborn¹ and Boodin.² Among the philosophers of the later age, Hegel, Lewes, Mill, Bain, Comte, Spencer, Lovejoy, Spaulding, Wundt and Broad have also given a careful thought to it ; but the real credit for bringing it to the forefront of the philosophical discussions of the day goes to Alexander, Morgan and Sellars. The idea has been received with open arms by many workers in biological sciences also such as Jennings, Ritter, Wood, Oslo, Holt and others. A careful consideration of it shows that its psychological affinities are with the doctrine of "Gestalt" of the German authors sponsored by Drexler, Koffka and Koelher. These authors believe that as the Reality shows novelties from time to time, it is necessary to suppose that the universe and the organisms in it must be acting as a whole. Here the emphasis is on the wholeness of the process. This kind of emphasis on the wholeness making emergence possible, is also advocated by workers like General Smuts,³ Whitehead, Broad and others, each one of which has his own interpretation of the idea of emergence.

There are several versions of the theory of Emergent Evolution and these have been summarised by McDougal⁴ (1929, pp. 237-264). Of all these accounts the scheme proposed by Principal C. Lloyd Morgan is very thorough-going and historically important as it comes from one who had been a friendly critic of Herbert Spencer, a staunch advocate of the laboratory methods in the investigations of the psychological problems and one of the four founders of the science of the Comparative Psychology of animals. He also had the rare privilege of being trained in the laboratories of the one of the greatest scientists and humanists of the last century, Professor Thomas H. Huxley. As McCabe⁵ (1910, p. 30) puts it : "He is perhaps the leading living authority on the animal mind—at least the mind of higher animals." At the same time he may lay some claim to the heritage of Spinoza through his master, Alexander whose monumental work, "Space, Time, and Deity" did much to lay the metaphysical foundations of the theory of Emergent Evolution.

Principal Lloyd Morgan was born in 1852 and was educated in a grammar school of the old type then prevalent in England. He received liberal education in Arts and philosophy and even in his young days chewed the difficult thought of Spinoza, and tried to think hard over the then thought-provoking book of Mivart, "*Genesis of Species*". Ever since that time he has been more interested in the general scheme of things revealed by nature rather than in any particular branch of scientific enquiry. And yet the science of animal psychology owes much to his masterly researches on the intelligence and instincts of animals. In this unique field of psychology he has many discoveries to his credit. Ever since he came under the influence of Prof. Huxley he devoted much of his time to the study of "Instincts of Animals", especially of higher vertebrates. He is thus, an ardent investigator by training, a scholar by habit and a philosopher by temperament. He knows well how and where

¹ Osborn, *From Greeks to Darwin*, 108.

² Boodin, *The Three Interpretations of the Universe*, 1934.

³ Smuts, *General Holism and Evolution*, 1926.

⁴ McDougal, W., *Modern Materialism and Emergent Evolution*, 1929, Mathuen and Co., London.

⁵ McCabe, J., *The Evolution of Mind*, p. 30, 1910, Adam and Charles Black Co., London.

to make use of scientific method of enquiry for ascertaining the facts and where to integrate them into a philosophical dissertation for comprehending the whole of truth. It is for these reasons that all his writings are distinguished by unique clarity of thought and lucidity of exposition. As Professor Warden⁶ has put it, "his writings show a broad sympathy and a sound scholarship in dealing with the more theoretical problems of comparative psychology that has scarcely been equalled." Being a philosopher scientist his method like that of Aristotle and Spencer, is what is called the *genetic method*. Having himself tackled many problems in comparative psychology he is a past master in the art of dealing with terse psychological subjects such as instincts, cognition, will, memory, images, etc. He is very thorough-going in collecting and presenting the data and has an admirable gift of putting the pros and cons of a point at issue in an intellectual controversy. At the same time he gives a clear indication of the view acceptable to him and the grounds on which he is inclined to accept it. In an attempt to know the whole truth he thinks that the scientific conclusions may be supplemented by philosophical explanations. To quote his own words: "we have just to accept newly given facts—facts as we see them—in the frankly agnostic attitude proper to science⁷." But the philosophical explanations are not substitutes for scientific explanations. They are rather to him supplementary to scientific explanations; and in the interpretation of the whole nature they should be combined in one naturalistic explanation. The incorporation of the last idea in his method makes him a naturalistic philosopher with a certain amount of mysticism in him; but the latter he brings in his explanations only under acknowledgment. In the following paragraphs a brief account of his theory of Emergent Evolution is given, based mainly on his "Gifford Lectures" delivered at the University of Bristol in 1923 and his subsequent papers.

DICHOTOMY OF NATURE

We live in an objective world the existence of which does not depend upon us. The world exists in its own right. However, we become aware of it subjectively through our senses by perception, *c'esse est percipi* as Burckley used to say. Behind this passing show there is Reality which seems to consist of two classes of objects, those given in space and those given in consciousness, the matter and mind. These two are so intimately conjoined, that in the world of our experimental knowledge they cannot be separated into two. The psychical and the physical thus are coextensive in our apprehension and the one does not exist without the other for us.

A question may perhaps be asked at this juncture whether the two classes of the objects proposed above are not one and the same thing like the Substance of Spinoza or the Absolute of Hegel? In reply to it we may say that as a pure philosophical dogma such an assumption may be justifiable but in a naturalistic way of explanation of the world, the consensus of opinion tends to regard them as two disparate orders of Nature, which are brought together by the projective reference of mind (cognition) of the higher vertebrates in the process of thinking. We may

⁶ Warden, C. J., "The Development of Modern Comparative Psychology," *Quart. Rev. Biol.*, III, p. 500, 1928.

⁷ Morgan, Cl. Lloyd, *Emergent Evolution*, p. 9, 1 23.

then ask what is matter and what is mind? and what is Reality? It is difficult to give satisfactory answers to all these questions. They are too stiff to be answered without going counter to the views of this or that author, mainly because in the thin air of metaphysics it is extremely difficult to define these categories. We can at best describe them in some such way as this: that which is matter is not mind; that which is mind is not matter and that which transcends both is Reality.

The passage of Reality shows an orderly sequence of events in the historical sense. Evolution, therefore, may be said to be an account of the natural history of Reality. Plainly speaking it is an interpretative story of the events as they occurred and are occurring in the universe. Philosophically speaking, as Morgan does, it is an ascending hierarchy of natural events in space and time, a plan of sequence of all the events in nature. No two events in the universe are unrelated and therefore a characteristic mark of Reality is the relatedness shown by its constituent events. From time to time these events show novelties in terms; and the process of evolution becomes discontinuous and jumpy at some critical turning points. The history of Reality can be viewed in different ways; but under the concept of Emergent Evolution the stress is on the jumpy nature of the process responsible for the emergent aspect of Reality. It is important therefore, to know what is meant by the emergent and what are its characteristics.

THE EMERGENT

The evolutionary process is not continuous. It is rather sudden at certain points and shows novelties at every sudden jump or level. It is not, therefore, merely repetitive but epigenetic also. The doctrine of emergence emphasises its epigenetic nature and is a continuous protest, as Morgan puts it, against the mechanistic interpretation which considers it to be repetitive only. To quote Morgan,⁸ "it is the very antithesis to one that is mechanistic." "It does not interpret life in terms of physics and Chemistry. It does not interpret mind in terms of receptor patterns and neurone-routes."⁹ "We should not say that mind is implicit in life, or life implicit in matter, but that vital relatedness is involved in the natural genesis of mind, and physico-chemical relatedness is involved in the natural genesis of life."¹⁰ It may be so. One would like to inquire next what distinguishes the emergent from the mechanistic? In the mechanistic interpretation the resultant effects are supposed to be an algebraic sum of the pre-disposing events and their characters. Under the concept of emergence, the resultants are there, but there is also the incoming of the new which is not the sum-total of the precedents and their characters. The emergent thus, is mostly unpredictable and unpredicted till it becomes a *fait accompli*. In the emergent evolution therefore the stress is on the incoming of the new which is not the sum-total of the precedents. At the same time to account for the incoming of the new no extra-mundane power or some *elan* or *entelechy* like those of Bergson or Dreisch is to be invoked by way of agencement. The emergence springing from the incoming of the new is due to the re-grouping of events either in their stuff or in their substance. New qualities and properties arise concomitantly during the process of re-grouping and are to be accepted with natural piety. As these accumulate a new level is set up.

⁸ Morgan, 1923, p. 10.

⁹ Morgan, *loc. cit.*

¹⁰ Morgan, *loc. cit.*, p. 113.

The evolutionary process advances from level to level, and at every new level there is emergence of new relatedness. There are innumerable emergent levels following each other very closely, but the following three are the outstanding levels admitted by Morgan : Life, mind and deity, with a secondary sub-level of consciousness in between life and mind. Others admit many more. For example, Wheeler¹¹ thinks that after the level of mind, the level of the social should emerge ; but as Morgan has stated there are innumerable levels of emergence in this manner throughout the rubric of the evolutionary process. At the highest level of the process there is emergence of deity to whom is to be attributed the ideal of the true, the beautiful, and the good. The theory recognises retrogressions also. There are many examples of evolution by what is technically called devolution and even mankind is not exempted from it. In this connection Wheeler says : "turning to man we notice a similar retrogressive development of the individual as the civilization proceeds. There is decline in the sense organs, the greater activity of the visceral nervous system and endocrine glands as shown by the higher emotivity, increasing insanity, criminality and mob-psychology in our larger cities etc." But inspite of such abject failures noticeable in many cases of animals and plants and the retrogressive cycles, the general trend of evolution considered as a whole, has been upward, and that is an important fact to be reckoned with. The mere descriptive or biographical story of evolution as told by sciences therefore, is not a complete account of the whole process. They mostly tell us as to how the process works but they do not tell us as to why it does so. That is the work of the interpretative philosophy. If one next asks then what makes the emergents emerge keeping the upward trend of evolution, sciences have no answer to give ; but the philosophy will ask us here to reckon with the principle of deity as an ultimate philosophical explanation on which the evolution depends, as a supplementary to the scientific interpretation admitted under acknowledgment. As such it is beyond any proof demanded by scientific method, or as a matter of fact beyond any disproof also. Such is the concept of the emergent in Lloyd Morgan's theory; and in the light of that we may now follow the interpretative story of the evolutionary process as given by him.

THE STORY OF EMERGENT EVOLUTION

The explanatory scheme gives an account of the evolution of life, consciousness and mind, the three large achievements of evolution by carefully formulating the concept of relatedness shown by natural events at several emergent levels. The events in the universe are not untidy but show consistence, coherence, and correlation. In other words, they are *interdependent and related*. The relatedness may be intrinsic or acquired. Due to the former the qualities arise and due to the latter the properties.¹² Characters comprise both the qualities and properties. New qualities arise due to emergence and the stuff is enriched thereby ; due to properties there is differentiation in the substance itself. But this is perhaps all vague. To take a particular example, the relatedness of the molecules of a crystal *inter se* is intrinsic, but their behaviour in

¹¹ Wheeler, W. M., *Emergent Evolution and the Social*, 1927, p. 18. Kegan Paul Trench Trenbner & Co., London.

¹² It is important to note here that Morgan (1923, pp, 183-188) makes a useful distinction between qualities and properties.

relation to the molecules of another substance in chemical combination is an expression of their extrinsic relatedness. The relatedness again is either *effective* or *ineffective*. Whenever it is effective there is emergence of new qualities or properties ; on the contrary the go of events is such that it is ineffective, then there is no emergence of new characters ; nay, sometimes even disintegration of the already existing qualities or properties may follow. The manner of going of events at any level is dependent on the new or emergent kind of relatedness which supervenes ; and it is that which controls and guides the events at the lower level. The events at each higher level are dependent on and involve the events at the lower levels. Thus, the temporal relatedness is evident everywhere in all the events in the universe, specio-temporal relatedness is evident in physical events, physico-chemical relatedness is evident everywhere at the level of life, vital relatedness is evident everywhere when the consciousness emerges, and the conscious relatedness is evident when the mind emerges. This sort of correlated dependence is called involution and gives rise to various systems in the universe.

In Alexander's system we begin with the time which is to him the mind of space. But in Morgan's system we begin with space-time systems, point-instances, and through the emergence of new characters ascend gradually to systems higher than these ones. From the space-time systems the physico-chemical systems emerge and constitute the matter. Life comes out of the former as an emergent attribute ; and though it is dependent on it, it can hardly be interpreted in terms of physico-chemical events only. With the emergence of life organisms come into existence and they are body-consciousness systems, and not merely living particles of matter. But at the lower level, such systems are having mere sentience e.g. in amoeba. From such simple systems at the lower level of life crops up the hazy un-unified consciousness e.g. that of snails, which gets organised in the higher groups that follow such as insects and the instincts arise. Even then the memory is wanting. The distant receptor-patterns develop gradually but the cognition is yet to come. With another advance of events the referential memory emerges and with it emerges the mind with its conative and cognitive processes. Organisms now comprehend not only by direct contact but also from a long distance by means of vision, hearing and images. Consciousness gets thoroughly organised into mind with its unique quality of reference in varied fields of experience and scans the sense data. This is the level of concrete cognition or what has been often termed the "projescent reference" by Sir Charles Sherrington and Morgan. With the emergence of concrete cognition, the whole outlook on the universe is changed, as it is the mind with its perceptual and conceptual qualities that is now at work. The reference is no longer only objective but perspective. The minding and what is being minded are united in one solidarity. Not only intuition or instinct but intellect also has come into play and they are all working together. "The intellect", says Morgan (1923, pp. 149-150), "gives an outer revelation of matter ; intuition is the pulse of life as it throbs and in throbbing is felt ; and life is of the order of mind. Now is the organism in action that is the "intersection" of the two diverse orders of being. Here is the focus of solidarity. Here is the meeting ground of antitheses. Here memory of one order (intuition) glows to specific consciousness in choice ; here the automaton of the other order, itself the embodied product of memory, is guided to

finer issues. Here the freedom of one order overcomes the rigid determinism of the other. Here the quality of one order meets the quantity of the other. Here time (duration) of one order comes into relation with space of the other. Here the flow of one order is in vivid contrast with the stark immobility of the other. Here the dynamic impulse of one order quickens the inertness of the other. Here process, change, progress—all that characterizes life—is felt on the one hand, while on the other is seen in static immobility their negative antithesis. Here, in brief, memory of one order is revealed as a kind of being that is, in all essential respects, the incommensurable opposite to retentive memory and matter of the other.” But a mere record of the past in the memory of an organism (retentive memory) will not initiate a change, as that is the work of mind. As Morgan¹³ says: “We must realise that it is the mind, as vital impulse, that is the efficient cause of all organic process and of all behaviour.” In mind the reference is not only to the past or present but to the future also. And here comes the purpose in the behaviour of organisms; and it is due to the entirety of the prospective reference and guidance, the two outstanding features of mind. When the mind has emerged and concomitantly with it the qualities of reference and all that is implied by them, there is a feeling of enjoyment, positive or negative, which keeps the onward trend of evolution at higher stages. It is true that in evolution there is also regress but that is regarded as “dissolution” by Morgan, and the whole tissue of Nature shows sometimes one sometimes the other and sometimes both at work side by side. In evolution there is building up of higher entities into wholes with substantial unity and in the dissolution there is scattering of the components which go together to constitute the whole. But on the whole “evolution has prevailed over dissolution—and there has been an advance in the direction of progress. At the highest level of evolution, in man, the evolution becomes threefold: evolution of enjoyment, objective reference, and guidance of the action; and in social and personal progress the guidance becomes more and more the expression of human purpose. It is guidance in the light of deliberate and thoughtful reference, with widening range of outlook. It is the guidance towards the personal joy in right conduct. More than that; it is guidance towards the sympathetic rejoicing in the joy of others which characterizes love and good will. Above all it is guidance in so acting as to promote evolution and to combat dissolution. For regress there is, our aim should be to fight it in all its forms. Here we have mind at its highest and best in social life.”

The efficiency of the whole system of events in the universe, however, does not depend upon the mere causation in terms of effective relatedness narrated above. Something more than the mere causation is necessary and that is Casuality. It is that which makes the emergents emerge and keeps them emerging. That is the principle of deity to whom are to be attributed all the good qualities in evolution and yet which does not fall within the perview of sciences. It is to be accepted, as Morgan insists, as a creed supplementary to scientific analysis. Because, to Morgan the casuation and casuality are not contradictory but co-extensive. As he puts it (Emergent Evolution, p. 292): “If in other words, we may acknowledge the physical events as ultimately

¹³ Morgan, *loc. cit.*, p. 150,

involved, and God on whom all evolutionary process depends; then we may with Kant, but on different grounds, accept both causation and casuality without shadow of contradiction." "It is He who draws all things and men upward in evolution."

To put in a nutshell, the emergent evolution works upwards from matter, through life to consciousness which attains its highest reflective and supra-reflective level in man. It accepts the more at each ascending stage as that which is given and accepts it to the full. "The most subtle appreciation of the artist or the poet, the highest aspiration of the saint are no less accepted than the blossom of the waterlily, the crystalline fabric of a snowflake or the minute structure of the atom." At the same time there is acknowledgment of the dependence of all things in evolution on God, the creative activity of which manifests itself through evolution. It is Morgan's firm conviction that there is one plan of evolutionary progress throughout the universe working in many a diverse ways. This is because as he admits, "I have been led, through my survey what seems to me to be the patent facts, to find one evolutionary plan as the manifestation of Divine Purpose (difficult as this may be to define) that I prefer the unrestricted usage of the word evolution."

CRITICISM

In our brief treatment of the theory of emergent evolution given above, the intelligent reader must have noticed some drawbacks in accepting it either as a philosophical explanation or as a scientific hypothesis. But in the face of such a grand scheme put forward by no less an authority than Lloyd Morgan, we should not make much of them. The first and the foremost good point that the theory has gained is the place it has secured for the incoming of the new in the evolutionary process. As Morgan has said, it is a continued protest against the mechanistic explanation given by men of science and against the preformationists in philosophical thought. It accepts the bifurcation scheme of nature as a part of its basic psychico-physical parallelism as a sort of compromise between dihard materialism and transcendent sensationalism. It shows a strong correlation between the facts observed and the philosophical explanations offered to explain them. Its strict adherence to scientific facts is commendable and this at once brings it into line with the theories of some of the great modern thinkers like Spinoza, Spencer, Bergson, Russell, and others. Explanation of various emergent levels offered by it is thoroughly naturalistic. It rules out dualism on scientific grounds giving monistic picture of the world. It is thus a true representative philosophy of the modern scientific age the attitude of which towards Reality often tends to indeterminism, uncertainty, and mysticism.

But in our appreciation of the theory, we should not belittle the difficulties which prevent us from accepting it whole-heartedly. On its philosophical side Lloyd Morgan's scheme rests on two important ideas: the recognition of matter and mind as two distinct orders of nature and the incoming of the genuinely new. The first one is obviously a Spinozan heritage and many critical authors would question the validity of this. Secondly, in Lloyd Morgan's scheme the mind knows the matter under the projescent reference, the memory of a person

being just the intersection of mind and matter. Apparently we have to incorporate here something of mind into matter and that is very much resented by McDougal. According to McCabe and McDougal mind has evolved as a factor in evolution from the passive sentience of amoeba to that of man, and it is not necessary to consider that mind has emerged as Morgan does. Regarding the creativity of the genuinely new, Stout and McDougal stoutly oppose the application of this idea to the inorganic things. They maintain that the genuinely new comes in the evolutionary picture only at the level of the conceptual thought. In other words, they deny the incoming of the new in the non-living matter like crystals, molecules and atoms. In these days of atomic fission, however, this is quite possible, *e.g.*, the production of Plutonium from the bombardment of the Uranium nucleus. They also contradict Morgan's idea of Nisus manifesting itself since the beginning of the evolutionary process, as they cannot find anything of mind in matter. The consciousness in organism and especially in man, is gained *ab initio* from its lowest level afresh in every child and recapitulates the story of its own development. There is nothing like the recapitulation of consciousness in the ontogeny of matter.

Another serious drawback in the theory is the assumption of the orderly progress and rationality in nature. In the face of misery and misbehaviour in this world, to speak of divine purpose and to make it responsible for the advance only and to exonerate it from all the responsibility of the dissolutionary processes and at the same time to say that the whole evolutionary process depends upon it is a proposition open to serious objections. Life with its blind alleys, animals with many haunts of parasitism, and the human society with an outstanding crop of criminals, malignents, and blood-thirsty monsters present a much stiffer problem of evil than has been solved by any system of philosophy today. Lloyd Morgan, of course, does offer an explanation of sin and evil; according to him sin is no part of the divine scheme. "Sin is not disintegration at a lower level that there may be further advance at a higher level. Sin is disintegration at higher level that events may run their course at lower level. It is purely retrogressive and in no valid sense contributory to progressive advance." But this is perhaps too optimistic and simple explanation of a hopelessly knotty problem namely, the problem of evil. Lastly, it is said that Lloyd Morgan's scheme of emergent evolution is merely a screen to cover his theological convictions. Nay, some of them, for example, McCabe, goes a step further and says : "Professor Alexander and Lloyd Morgan are chiefly concerned to save God and the coherence of the evolutionary scheme." But this is perhaps, too unjust a criticism of the whole of his theory, since the explanations given by him are thoroughly naturalistic and are not inconsistent with the facts known to science. He only chooses to give a different interpretation of them. In this connection it must also be remembered that he brings the deity and divine purpose in his scheme not as a part of scientific explanation but only under acknowledgment. The emergence of deity is only at the top level and is not in evidence at any lower levels ; and though the process of evolution shows dependence on it, in no way it bears a causal relation to it. In other words, Morgan attempts to give a monistic picture of the universe with an emergent quality of deity at its apex without any causal relation to that system. But here it may be argued that as such his theory is not

distinguishable from pluralism or materialism and one may ask the same question which Boodin¹⁴ asks : "What is the use of throwing out dualism or pluralism through the front door of speculation, if we admit them through the back door in our final attitude towards reality?" These are some of the difficulties in accepting Lloyd Morgan's theory as a philosophical explanation of nature. We may next consider how far it can be accepted as a scientific hypothesis.

From the view point of science an important point in Lloyd Morgan's theory is the recognition of the emergent. Two cognate facts associated with the emergent are the discontinuity of the process and the novelties. Many workers on live objects today will readily grant the principle of discontinuity in the light of the work of Bateson, Vavilov, De Vries, Gulick and others. The principle is well recognised even by a staunch Darwinian like Professor Seward. Side by side with the discontinuity there are novelties in evolution which also will be granted by many in the light of the recent work on the cytology of animals and plants. The fountain of change in an organism, the chromosomal complex, though looks apparently so fixed, has many ways of undergoing changes and bringing about new combinations of characters through genes. It is in the behaviour of the chromosomal garniture of organisms lie the freedom and creative principle of novelties. But for a student of science the mere recognition of novelties is not enough. What is more important for him is to prove that they are really new things in the course of evolution. And that means he has to ascertain how far a particular fact claimed to be new can or cannot be explained by the mechanistic or the preformationist view. For a student of science, therefore, it is necessary to show that emergence is a matter of fact rather than a matter of interpretation.

The other difficulty in accepting Morgan's scheme as a scientific theory is concerned with the great gap it supposes to exist between the mental and the non-mental. The assumed psycho-physical parallelism in Morgan's theory, as has been pointed before, is resented much by some workers. McCabe¹⁵ for example shows that it is not necessary to suppose that the mind has emerged *de novo*. He rather tries to show that it has been gradually evolved through the simple consciousness of amoeba to that of man and that there is no discontinuity in it as Morgan suggests. Jennings, on the contrary, who is a notable worker on the behaviour of the protozoa faintly admits that mind is an emergent entity.

A third debatable point in Morgan's theory is the hiatus it supposes to exist between the living and the non-living. This is a very vexed question and nothing definite can be said on it. McClung,¹⁶ the celebrated American cytologist, in his recent article points out many similarities between the behaviour of the units of the living and non living matter and yet he cautiously adds: "How can the origin of living units be conceived? There is but little positive knowledge to which we can turn for the answer of this question." Many workers have tried to solve this

¹⁴ Boodin, 1934, *loc. cit.*, p. 135.

¹⁵ McCabe, J., *The Evolution of Mind*, 1910. Adams and Charles Black, London.

¹⁶ McClung, C. E., "What of the Future," *Amer. Naturalist*, Vol. LXXIV, p. 51, 1940.

problem in their own way and have put forward many tentative hypotheses also but nothing can be said definitely about it. The only thing we know for certain is that the living matter to a large extent depends upon the non-living matter, though it cannot be reproduced from it. The dictum *omne vivum e vivo* alone holds good as far as our present knowledge of the living objects goes. Many chemists and physicists have contended such a claim of biologists and still it has been repeatedly upheld by workers on living things. Under the circumstances, therefore, there seems to be no escape from the conclusion that there is sufficient justification for the gap assumed to be present between the living and the non-living in Lloyd Morgan's theory.

Lastly, in Morgan's scheme there is an acknowledgment of the creative principle of deity, the emerger of emergents, on account of which there is progress in evolution. But since this is admitted under acknowledgment only, and is not evoked to explain any of the basic facts, it does not fall within the ken of the scientific enquiry. The students of science may safely glide over it and straight away proceed to verify the various assumptions in his theory by further enquiries. Because, in matters of science one is not bound to accept anything of the nature of a creed or acknowledgment, as it is highly detrimental to its progress. The duty of science is to verify; and it seems to me, that in that direction lies the progress of this new theory of evolution.

History of the famous laws in science will bear a testimony to this fact. Almost all of them started as wide philosophical generalisations and ended in natural laws as working hypotheses in explanation of certain facts through an intermediate stage of verification. It is evident that Principal Lloyd Morgan's theory is in the second stage. Like the idea of Organic Evolution the idea of emergence also has been much in the mind of the workers right from Lucretius to Mill but the added significance it has gained today is due to its searching analysis made by Alexander, Morgan, Sellars, Smuts, and Broad. At present the theory of emergent evolution, as Morgan puts, it is purely an interpretative story, but it is expected that it will soon creep down to science as a working hypothesis from the realm of philosophy. Nay, it has already done so. There is a band of workers like Ritter, Osborn, Jennings, Lillie, Wheeler, Holt and others who think that the idea of emergence is the magna charta of biological sciences and are busy persuing it as a working hypothesis. In matters of science it is useless to be dogmatic over any hypothesis. Whatever will stand the test of verification will alone survive; and though it is doubtful whether what Morgan admits under acknowledgment, namely the principle of deity and divine purpose in evolution, will ever stand this test, it is highly probable that the remaining part of the theory may stand it. Who could have felt compelled to accept the theory of Organic Evolution before Darwin? And, who can say that another Darwin may not emerge with an array of imposing facts to substantiate the theory of Emergent Evolution? The opinion of every student of science on this theory, therefore, must be a matter *sub judice*.

FUNCTIONS OF CRITICISM*

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AN attack on the problem of the functions of criticism may begin with a consideration of the fact that *criticism* has in common parlance been regarded as synonymous with *fault-finding*. To criticise an action is usually to express disapproval of it, to be critical of a person's character is to reveal various undesirable aspects of it. Traditionally the literary critic has been thought of as a hanging judge who passes sentences of varying severity on poems and poets. It was by way of turning the tables upon the critic that Ben Jonson said in one part of his *Discoveries*, "But some will say, critics are a kind of tinkers, that make more faults than they mend ordinarily." The tradition of regarding the critic as a kind of detective and hanging judge rolled together is based upon the acerbities and acrimonies of literary controversies and critical judgments in the past. Criticism was a weapon in the warfare between rival poets and playwrights : the purpose in view was to blackball an enemy rather than to arrive at an impartial and discriminating estimate of the literary value of a poem or a play. Thus, Greene's attacks on Marlowe and Shakespeare and the personalities of Nashe, Harvey, Lodge and the rest in the Elizabethan age were a characteristic exhibition of blackballing criticism. In *The Frogs* of Aristophanes the rival tragedians, Aeschylus and Euripides, are engaged in a fault-finding match.

The point that emerges from these facts is that it is the nature of criticism to be *critical* in the popular sense of the term. It will be wakeful and Argus-eyed, keen to expose shoddy work and counterfeit effects. Criticism that turns soft and goody-goody is far more harmful to the cultivation of genuine literature than criticism which errs on the side of hardness and severity, provided always that it is disinterested and impersonal, dealing with the poem and not with the life or character of the man who has composed it. The need for emphasising the obligation on the critic to be duly severe and critical seems to be urgent when one remembers that so much of contemporary reviewing and criticism has become a matter of log-rolling, mutual admiration and sugary, inoffensive generalities. Good manners are undoubtedly useful as a lubricant in social relationships, but they should not make the critic feel awkward about exposing and commenting upon artistic faults and imperfections in the poems or plays which are being criticised. It is more important that the critic should confront the poet with the steep and thorny way to perfection than that he should accompany him along the primrose path of dalliance.

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The 'ending end' of literary criticism, as Sir Philip Sidney would say, is the final placing of a work of literary art, the estimation of or judgment on its artistic excellence, its evaluation. That is the all-embracing, ultimate function and achievement of criticism. But there are a number of other objectives and functions, in various ways contributory to the main function, which inform and motivate a good deal of critical activity. Thus, there is criticism which confines itself to the exposition and interpretation of the text, which is primarily an aid to the proper reading of a book. There is, secondly, the kind of criticism which is absorbed in literary appreciation, which expresses the enjoyment of a book by one reader, the pleasurable impressions made on him by the poem. There is, further, comparative criticism which sets the selected book or author, for comparison or contrast, against other books or authors,—a typically *critical* activity, as it weighs the relative merits and demerits of various pieces of writing. And, finally, there is evaluative criticism which passes judgment on the absolute value of a poem or a play, which assigns it to its place in a scale of perfection, an order of merit. This enumeration of the different objectives placed before themselves by literary critics is not intended to be exhaustive : it is rather suggestive and representative of the main tendencies. Nor is there an intention to establish an ascending scale of values among these objectives. Each is useful in its own way, and has its own field of activity : it need not come in the way of the rest. Frequently, a single piece of critical writing will be found to have more than one function. The intention is to make the student aware that many different lines of study are indicated by the title, literary criticism.

The starting point of literary criticism will always be an attentive reading and study of the text. Literature in its external form is a series of word-symbols printed on the page in a certain order. The reader takes the symbols in with the eye and seeks to get through them at the meaning intended to be conveyed by the writer. The critic, who is above all a trained and experienced reader, will offer his help in the business of interpretation and right understanding. Unlike a scientific piece of writing, a literary text is based upon a many-dimensional use of language. While science achieves clarity by attaching precise, logical, unambiguous values to the word-symbols, literature achieves significance by playing upon the subtle, shifting associations, forked ambiguities, rhythmic and auditory values of words and phrases. Allusions to lines, phrases and contexts in other poems or plays as a means of expression, uses of suggestive imagery remove a literary text still further from the directness and simplicity of scientific writing. The resources of the common reader are likely to be limited, his knowledge of the references and allusions restricted by the narrow range of his reading. That is why for the interpretation of the subtler and more complicated type of literary text he is glad to avail himself of the help given by the expert critic. In this sphere the business of criticism is to remove obstacles and clarify obscurities which may hinder or baffle the reader. Thus an exposition of the Elizabethan theatrical conventions and stage conditions may be necessary for a proper understanding of the structure of a Shakespearcan play. A passage from Dante will reveal the inwardness of its significance when it is collated with certain aspects of the poet's personality. The layers of literary allusions in *The Waste Land* of T. S. Eliot will have to be mined in the process of illuminating the admitted obscurity of that poem. The daringly experi-

mental word-coinages of G. M. Hopkins and James Joyce will require critical guidance for their proper interpretation. There is the all-important question of imagery. A great literary artist seeks to achieve the impossible—to capture the grace beyond grace, the meaning beyond meaning, “Which into words no virtue can digest.” Delicate complexities of thought and feeling, subtle poises and resolutions of apparently discordant and contradictory conceptions and attitudes, experiences which are composed out of elements from the conscious, sub-conscious and unconscious levels and layers of the human personality,—these form the significance of and give an inestimable value to passages from the greater plays of Shakespeare, some of the poems of Donne, some parts of the novels of Conrad or D. H. Lawrence. It is only by an original, profoundly suggestive, dynamic use of the different kinds of imagery—conceits, metaphors, symbols—that the masters have succeeded in giving a form and pressure to these imponderables. Here no question of wilful obscurity arises : no simple, direct, common sense use of language can do the job. Imagery is strictly indispensable in the higher reaches of the literary art.

It will be a peculiarly important and responsible function of criticism to unfold the hidden suggestions of the images and make legible the meaning of the hieroglyphs. The critic has to train himself in the art of interpreting imagery as the psycho-analyst is trained in the art of interpreting dreams. He will take the reader by the hand and show him how to take imagery as the centripetal way to the core of the poem’s significance. Of course it will not be necessary in every instance for him to guide the reader step by step : it will be enough if he points the way and initiates the process of interpretation. In criticism as in other spheres of life it is important to avoid the danger of murdering to dissect. While line-by-line analysis is in difficult passages a useful tool of interpretation, there have been cases where it has

“ broke ope
The Lord’s anointed temple, and stole thence
The life o’ the building.”

The criticism of exposition and interpretation has had a long and honourable tradition. Its tendency in the past to occupy itself unduly with grammatical and syntactical regularities has now been overcome and, in the hands of critics like Dr. Richards and F. R. Leavis, it is developing into an extremely valuable method.

If literature is above everything else a form of entertainment, one of the important functions of literary criticism must be considered to be to promote its appreciation and enjoyment. It may be taken as axiomatic that readers will not bother to turn the pages of a book “if the prospect of delight be wanting.” One of the reasons why literature takes a high rank among the agencies that foster human culture is that it is capable of developing in men the capacity for feeling “The joy in widest commonalty spread :” the disinterested delight that readers find in literature is but a reflection of *joie de vivre*. While interpretative criticism enables the reader to come to a proper understanding of the text and thus provides an indispensable preliminary, appreciative criticism gives wings to his spirit by showing him the pleasure which an experienced reader has derived from the poem. What is implied in the long-established

tradition of acknowledging the critic to be a man of *taste* is that he is an epicurean in the field of literature, one who derives intense and refined enjoyment from the reading of books. He reads for pleasure and he writes to express and communicate to others the pleasure he has derived from books. While in interpretative criticism the critic is in the background and seeks to remain invisible behind the exposition and commentation of the text, in appreciative criticism he has necessarily to come into the foreground and talk about the experiences, emotions, trains of thought and association which the reading of the book has started and stimulated in him. He is talking about himself as affected by the book, revealing his personality in the act of responding to a literary stimulus. Appreciative criticism is a lyrical, subjective form of writing : by means of it the critic achieves self-expression—not as a man of the world but as a man of the world of books. It is in its purest form a poem on poem like Keat's "On looking into Chapman's Homer."

Of necessity, appreciative criticism throbs with emotion and is warmed by enthusiasm. The cool calculation, the subtle poise, the wise balance of some other forms of criticism is antipathetic to its nature. The responses it registers are occasioned by the reading of a book, but they are more likely to conform to the nature of the reader than to the nature of what he has read. The book has suffered a sea-change when it has been absorbed by the critic into his own consciousness and personality. It has become the critic's *Hamlet* or *Antony and Cleopatra* : it has clothed itself in the colours of the critic's imagination. To condemn appreciative criticism for being a creative, emotive kind of writing is to condemn it for being true to its own nature and for performing its proper function. It aims at making the reader interested in the book, stirring his curiosity and heightening his expectations: it reaches that aim by giving a glowing account of the pleasurable impressions printed by the book on the mind of the critic.

Appreciative, impressionistic criticism takes a book by itself, enjoys it and admires it as a thing apart. It savours the sweets that lie compacted in a poem and rests for the time being in the poem's individual flavour. It has a childlike quality of living completely in the present moment, without looking before and after: the quality cultivated by Pater's Marius the Epicurean. The development into maturity proceeds by way of comparative criticism. A literary work of art does not stand by itself in splendid isolation. It is related to other works of art by community of aim and kinship of origin : it has been inspired by the author's loving study of other pieces of literature, it represents a particular variation and branching out of literary tradition. A completely original, *sui generis*, incommensurable work of literary art does not exist for the simple reason that it participates in a continuous tradition. Even a symbolist poem or a surrealist text proves on examination to have an umbilical connection with the more classical, conventional types of composition.

It is this situation which gives comparative criticism its cue and its function. After the critic has thrown himself into the poem and felt his whole being suffused with its tidal current, after he has lived in and lived through the poem, he has to come out of it and hold it at a distance, get his bearings on it by reference to other poems which belong to the same plane. A comparative study of different works of literary art not

only establishes points of contact, of similarity and difference in aims of writing and employment of devices which are serviceable for the interpretation of the several pieces of writing and an appreciation of the art of the writers but develops into an estimation of the relative achievements and artistic values of the pieces that are being compared. There is no such thing as a transcendently beautiful poem, a completely successful play; there are more or less beautiful poems, more or less successful plays which admit of a relative valuation. A comparative study will also make it clear that the very success of a poem in one respect involves its failure in other respects, that variation from the old pattern implies both loss and gain, that each kind of writing and form of literature has a best of its own, an ideal perfection to which individual specimens of the kind approximate more or less closely.

Comparative criticism may follow a number of different leads. It may go by origins and influences, relate the aims and methods of an author to those of the masters from whom he derives and by whom he is inspired: it will trace Marlowe's artistry to Spenser and the mature Keats to Dante, not as a matter of historical occurrence but as a method of estimating critically the relative superiority or inferiority of the artistic achievement of predecessor and successor. It may go by kinds and forms of literature, comparing novel with novel and tragedy with tragedy, estimate within each form the respective excellences of the different historical variations—set Greek tragedy against neo-classical, Senecan against Elizabethan, realistic against romantic, or, crossing a continent and bridging the gulf between civilizations, place the Greek *Iliad* and the Sanskrit *Mahabharata* together as specimens of the art of epic poetry. It may work by ages and periods of literature, setting the artistic productions of an age against the intellectual, moral, social background of that age, trying to form an idea of the spirit of the age and the way in which it inspires the literary art of the age, comparing the artistic aims, methods and achievement of different ages by means of a detailed study of selected examples. Thus the Elizabethan age may be compared with the Augustan, the novel in the age of Fielding with the novel in the age of Thackeray; or the intellectual and social background of the Seventeenth century may be studied for its bearings on the nature of Metaphysical poetry. The principle of comparison and contrast is capable of endlessly varying applications and eminently valuable results in the hands of a critic who never forgets that literature is his subject matter and that the critical weighing and estimation of artistic achievement is his main function.

Evaluative criticism seeks to arrive at a definitive judgment on the final, ultimate value or worthwhileness of a literary work of art in and for itself, as well as to determine its place and magnitude in the galaxy of literature. It has the seriousness and finality of the Last Judgment in the sense that it is based upon an adequate ordering and weighing of all the relevant factors. Verbal felicities, structural stresses and balances, range and importance of the experiences laid under contribution, inclusiveness and clarity of the vision of life communicated by the poem—these and other aspects of the work of art must be seen and considered in the order of their importance, the genuineness and degree of the organic functioning of its parts must be tested and measured, the apocalyptic power of its "criticism of life" must be assessed, both

absolutely and relatively to comparable works of art, before a final evaluation can be effected. Evaluative criticism will of course take account of and profit by the findings of other forms of criticism. It will learn from interpretative criticism to put a proper construction upon the words on the page, it will live through and live in terms of the poem, led by the hand by the Beatrice of appreciative criticism, it will use the methods of comparative criticism for seeing the poem in the round and establishing its relationship with other poems and works of art. It will concentrate all the light that can be derived from knowledge of literature : but it will go beyond literature to life, the origin and the fountain of the light of knowledge, and place the mirrored image by the original, the reflection by the reflected. In the final estimation literature cannot be considered in isolation from life : it must show itself to be attuned to life, throbbing with the heart-beat of life. The superiority of *Macbeth* to *Sejanus*, of *The Divine Comedy* to *Paradise Lost*, of Wordsworth to Shelley and of Keats to Tennyson is ultimately justifiable on the ground that the one gives a deeper and more acceptable meaning to life and experience than the other. It is not a matter of the glory of single passages and the splendour of isolated images : it is a question of ultimate values—values for life, values in terms of life. With the answering of that question literary criticism has discharged its ultimate function, its heavy responsibility : it can then resume the more congenial activity of the enjoyment of literature.

A NOTE ON BUDDHISM AND BERTRAND RUSSELL

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IN this small note I propose to show that there is a very striking similarity, nay, almost identity between the Buddhist view of Reality and the philosophy of Bertrand Russell.

The present metaphysical stand of Russell can, I think, be summarized in the following three points :

(1) The ultimate constituents of the universe are not particles, but events or occurrences. These are the "stuff" for physics. (I think it was something very like this that Leibniz hinted at, by holding that a monad cannot exist except by its *activity* of perception and appetition).

(2) These events are absolutely particular. There are no substances either physical or spiritual to whom these can be ascribed as modes. I quote Russell : "'Substance,' in fact, is merely a convenient way of collecting events into bundles...What is Mr. Smith apart from all these occurrences?" (History of Western Philosophy, p. 224). "I think both matter and mind are convenient ways of grouping events." (*Ibid.*, p. 861).

What we call "the thing" is a series of events (in his earlier works Russell used to add "of a very brief duration." Now he does not do it in view of the Relativity Theory), which form a relatively isolated causal chain. In the case of our perception, the members of the series (particulars) closely resemble each other ; the more so the nearer they are. When we say "I see the table," philosophically speaking, both the "I" and "the table" are logical fictions. Both of them are series of events causally linked.

(3) It does not mean, however, that there is anything in the event we call "cause" that *compels* the occurrence of the succeeding event, the effect. They are each self-contained. "Causality" is the name we give to certain logico-mathematical properties of the structure of the series. The members of the series follow each other in a brute succession, each unaware, so to say, of the preceding and the succeeding member.

Thus, briefly, Russell. Turn we now to the Buddhistic thoughts and compare it with Russell's in the three points above stated.

(1) According to Buddhism, existence or being is identical with causal efficiency. This theory is called by the Buddhists कथंविद्यमानमित्येतत्. They held that nothing can exist except by functioning in some manner or other, just as Leibniz held that a monad cannot exist except by its

activity. They were, however, more thorough going than Leibniz in that they did not ascribe the activities to an agent. Like Russell, therefore, they held that there are only events or occurrences, and not "things" in some more reputable sense. In *Bodhicharyāvataṛapaṇjika* (IX, 6) we read "भूतिर्विषयं क्रिया सेव ।" whose very being consists in activity. The Bhāvas of the Buddhists are nothing other than Russell's events.

(2) Next, they defined a thing as the series *वृत्ति* or aggregate *संचात* of such events or Bhāvas. What we call a चट (pitcher) is according to them a चटसंतान, i.e. a series of momentarily existing pitchers. And what is taken to be the चट of the moment is nothing apart from the संचात (aggregate) of the various qualities, Bhāvas, we perceive, which are all only occurrences. This is the doctrine described as *नैरात्म्यवाद* (non-substantiality). In this connection we get the analogy of a chariot in the *Milinda-praśna*. It is said there that there is no such thing as the chariot apart from its various parts. It is only a name for the संचात. Now, compare Russell: "Anyone can see in the analogous case of a geographical region that such a word as "France" (say) is only a linguistic convenience, and there is not a thing called France over and above its various parts. The same holds of Mr. Smith; it is a collective name for a number of occurrences."—*History of Western Philosophy*, p. 224. (It is true that in later Buddhism there arose a school which took these occurrences to be exclusively mental—a view which Russell would never assent to. But this addition is quite irrelevant to the main argument. Besides, it is interesting to note that in early Buddhism the self was taken to be an aggregate *both* of psychical and physical events—a view which goes half-way to meet Russell's doctrine of "neutral stuff." Further, we should note that just as Russell explains the perception of the "same table" by saying that the particular perspective tables are closely similar (in his "Problem of Philosophy") so also *Vijñānavādin* Buddhists explain the perception of the same pillar by saying that the various momentary pillars forming the संतान are closely similar.

(3) Further, the causal connection between the members of a संतान (series) is viewed by the Buddhist in much the same manner as a Logical Positivist like Russell would do. Their doctrine of causation is called *प्रतीत्य समुत्पाद* which literally means "This happening, this happens." By this they wanted to emphasize the self-containedness of each event or Bhāva. They wanted to point out, what Hume pointed out in the 18th century, that the nature of an event which we call cause is indifferent to and independent of the nature of the event called the effect. That the *प्रतीत्यसमुत्पाद* doctrine implied this becomes clear from the following exposition of the theory by वाचस्पति in his भाष्यति.

"असति पुष्पे फलं न भवति...सति पुष्पे फलं भवति...तत्र पुष्पस्य नैवं भवति ज्ञानमहं फलं निर्देयार्थमिति, फलस्यापि नैवं भवति ज्ञानमहं पुष्पेणामिति विततिमिति...

All this means that each member of the causal series is self-contained. To put it metaphorically, each is unaware of its predecessor or successor. The series, in fact, is what Russell may call a "brute" concatenation of events.

The only thing the Buddhist could not do was to analyse the causal relation into logico-mathematical properties. But this does not much detract from the metaphysical value of this ancient doctrine.

THE ABOLITION OF PERSIAN AS COURT LANGUAGE IN BRITISH INDIA

BY J. K. MAJUMDAR, M.A., PH.D. (LOND.), BAR-AT-LAW

THE abolition of Persian as court language in British India by the authorities of the East India Company in 1837 may be said to have been done more on political grounds than on the alleged economic one. Since the days when the Great Moghul came under British protection after the second Mahratta war in 1803, the great political game of the establishment of the British paramountcy in India started, at first rather covertly, and then more and more overtly with the progress of time and the feeling of the security of their empire here.* A bold and forward policy was started in this respect from the time of the Governor-generalship of Lord Moira, when it became a part of the British political scheme to put down more effectively the fiction of the Delhi Empire, i.e. to abolish in a consistent manner the last vestiges of the Moghul power and dominance in India; and the substitution of the English and vernacular languages in the courts for the Persian may properly be said to be a necessary and important part of the above scheme. The occasion of the renewal of the East India Company's Charter in 1833 may be said to have given the desired opportunity to the authorities to review *inter alia* the judicial system of India, and in one of their questions put to Raja Rammohun Roy, the great Indian reformer and leader who was the only representative of India to give evidence on the subject, the Parliamentary Select Committee took care to ask his opinion if it would be advantageous to substitute the English for the Persian as the language of the courts. The Rajah was careful to reply that though it would have the advantage of being the vernacular language of the European judges, but with regard to the natives, it would have the same disadvantage as the Persian, being a foreign tongue, though, he opined on a higher ground, that its gradual introduction in the courts would, notwithstanding the disadvantage, prove ultimately beneficial to them by promoting the study of English, which, he thought, would help to diffuse the light and knowledge of the West and be conducive to the amelioration of the intellectual and moral condition of the British subjects. However, we cannot discuss this subject here. The present dissertation giving a short history of the abolition of Persian as court language in British India, being based on some unpublished records of the East India Company preserved in the archives of the Government of Bengal, would, we hope, prove of interest not only to the historian, but it would be no less so to the curious also, as it throws very interesting sidelights on the superior position of the Persian in relation to the other vernacular languages of the time, as well as of its popularity even with the Hindus.†

* *Vide Majumdar : Raja Rammohun Roy and the Last Moghuls, (Calcutta, 1939).*

† It should be noted that Raja Rammohun Roy, himself an accomplished Persian scholar, in his noble endeavour to enlighten his countrymen adopted the means that the Press provided, and of the papers that he started one was in Persian, as it was understood by all the respectable part of the native community. *Vide, Majumdar : Raja Rammohun Roy and Progressive Movements in India, (Calcutta, 1941).*

Shortly after the new Charter Act came into force in 1833, we find the Court of Directors of the East India Company in their dispatch, dated the 26th June, 1835, write to the Government of India asking if they had any objection to the discontinuance of Persian as court language. Para 23 of the dispatch says :

"As the abolition of the Persian Language in the Judicial Department would lead to a considerable diminution of expense and as that language is not at all used at Bombay and only in two instances at Madras, we desire that you will state for our consideration, any particular circumstances, if there be any, which render the continued use of that language desirable in the Judicial Departments."*

In compliance with the above desire of the Court, the central Government here asked the provincial authorities concerned to submit to them their sentiments on the subject. The provincial authorities again, on their part, directed the Sudder Dewany Adawlut in their respective provinces to ascertain the views of the judicial authorities under them on the matter and submit them with theirs at an early date. Accordingly, we find the authorities of the Sudder Dewany Adawlut at Fort William, Bengal, and the North-West Provinces issuing circulars to the Commissioners of Circuit, Civil and Sessions Judges, Magistrates and Joint Magistrates requesting them to submit their opinions on the point, and in the event of its appearing to them that any advantage would result from discontinuing the use of the Persian as the language of the Courts to state what language they would propose to substitute in its place, as well as whether the change would be attended with any and what reduction of expense.

In compliance with the above request we find the authorities of the Sudder Dewany and Nizamut Adawluts of the North-West Provinces, after ascertaining the views of the local subordinate authorities, submitting their views which were not favourable to the discontinuance of Persian as court language, neither did they think that it would prove more economical. It is interesting to note their points of argument submitted in their letter, dated the 29th July, 1836, to the Lt.-Governor of the North-Western Provinces, which reads as follows :

"With reference to your letter under date the 11th December last and its annexed extract of a dispatch from the Hon'ble the Court of Directors, requesting the Court to state whether with advertence to the reduction of expense which the Hon'ble Court appear to suppose would result from the abolition of the Persian language in the Judicial department, any particular circumstances exist to render the continued use of that tongue desirable as the medium for the transaction of Judicial business, I am directed to acquaint you for the information of the Hon'ble the Lt.-Governor, that previously to submitting their report, the Court thought it proper, upon a question of such general interest and importance, to call for the opinions of the local authorities subject to their controul; and I am now directed to submit for His Honor's consideration, the accompanying original returns as per annexed list received from the officers in reply.

"It will be observed from these reports, that the opinions of the local authorities on the subject under enquiry, are nearly balanced : 33 having declared themselves in favor of the introduction of the Hindoostanee language in lieu of Persian into all the courts of these Provinces, principally on account of its being the vernacular tongue of the country, while 29 are opposed to the measure, as calculated materially to impede the dispatch of business and to add to the expense of the Judicial establishment, without conferring any corresponding advantages.

* Judicial Consultation (Civil), 16 Feb., 1836, No. 10.

"The Court have already, on a former occasion, in reply to a requisition from the Right Hon'ble the Governor General, submitted their opinion of the inexpediency of discontinuing the use of Persian as the official language of the Judicial department--they observed on that occasion, that independently of other considerations, they apprehended it would be found impracticable in the existing state of education in India, to substitute the English language in its place, and that the vernacular tongue of the country was notoriously ill adapted to the purpose, from the diffuseness of its idiom, the slowness with which the character was written, and the very great difficulty experienced in reading it readily; added to which, the variety of its dialects, differing generally in every district, and frequently in the same, according to the different classes of the inhabitants, on which account it has been found necessary to require for the use of the superior Courts in cases referable to them, translations in Persian of all documents which may have been recorded in the first instance in any other language, would appear to offer a serious, if not an insurmountable objection to its adoption. A copy of the Court's letter above referred to, is herewith submitted for the information of the Hon'ble the Lt.-Governor, and I am directed to state, that the majority of the Judges who now compose the Court, concur in the sentiments therein expressed.

"With regard to the reason assigned by the Hon'ble Court for the abolition of Persian, viz. "that it would lead to a considerable reduction of expense," it will be observed, that with two or three exceptions only, the officers whose opinions are expressed in the accompanying returns, agree that no reduction of expenditure could be calculated upon from this source; but on the contrary, that at first until the officers of the Courts had become accustomed to the transaction of business in the new official Dialect, the present establishments would scarcely be found equal to the duties required of them, which already fully occupy their time; and a temporary increase would probably be indispensably necessary to prevent the business of the Courts from falling into arrears, while supposing the difficulties incidental to the introduction of a new official language to have been overcome, the same number and description of native officers would be required as at present, and equally well qualified individuals could not be obtained on smaller salaries.

"I am at the same time directed to request you will submit for the consideration of the Hon'ble the Lt.-Governor, the accompanying copies of minutes recorded by two of the Judges of the Court (Messrs. Ewer and Dick) on the subject under enquiry."

"Mr. Ewer's Minute :

"The introduction of a novelty however desirable is generally at first attended with a certain degree of inconvenience which we soon lose sight of in the advantages by which the new measure is attended. It will not I apprehend be denied that the substitution of the language of a country for a foreign tongue in law proceedings, is desirable as a general rule; it is only asserted that this country should be excepted, and that not even an attempt at the substitution should be made; not even a partial experiment.

"I cannot consider the grounds stated for a rejection of Hindoostany to be sufficient. The diffuseness of its idiom is rather in its favor than otherwise, for it would prove a formidable obstacle to the endless repetitions and useless remarks in which the opposite quality of the Persian enables a writer to indulge--only allow the same time for the preparation, and a plaint in Hindoostany would not be one quarter the size of one written in Persian and would contain as clear an exposition of the claim without the irrelevant matter. At first I would allow the use of the Persian character, and this is not at present uncommon particularly in Behar. The differences of dialects would not affect the Pleadings in any important degree and the Decree not at all.

"As to English, I would for the present, confine it to a note by the Judge containing the grounds of his decision should he reverse the Decree of a lower court; this would be attended neither with difficulty nor delay but no further use of English is at present practicable.

"The details of a Decree are well set forth in the 7th Paragraph of the Court's letter of the 8th June, 1832 but the attendant advantages of this mass of repetition are not put in so clear a light. Beyond a statement of the claim and Defendant's answer, substance of the pleadings and evidence need not be given, nor the grounds of decision by the lower court, nor those of the upper, if confirmatory; a final Decree of this court need contain nothing further; and the same rules as far as applicable, may be observed by the Lower Courts.

"The great fault of the country courts is, the encouragement they give to the introduction of useless repetition and irrelevant matter in pleadings, and repetitions by adopting the same style in their Decrees, with great loss of time to all parties concerned.

"By way of experiment, I would recommend that depositions in criminal cases before the Session Judge be taken in Hindoostany, and that pleadings, petitions of appeal, or miscellaneous, and decrees in the civil courts, should be drawn up in the same language and in the Persian character.

"Our own habits are not to be taken into consideration in discussing a measure of this description and of such public importance, still less ought we to regard those of the officers under us; and I must say that unless we are prepared to prove that the retention of Persian is reasonable and just towards those who do not understand it at all, we ought to adopt, or anyhow try the other language to which they are at least more accustomed, and reject all consideration of temporary inconvenience."

• The 14th July, 1836.

"Mr. F. Dick's Minute :

"The Court of Directors would appear to assume as an ascertained fact that the abolition of the Persian language and consequent substitution of some other, would lead to a considerable diminution of expense; perhaps, it is rash for us, who are ignorant of the grounds on which the Court have determined that point, to offer an opinion on the subject : it certainly appears to me the abolition of the Persian language would not be attended with any reduction of expense ; on the contrary, during some years after the change, until the native officers shall have acquired a readiness and facility in writing the character and transacting business in either Hindoostany or English, a greater number of public officers, than are at present entertained, will be required to get through the quantity of business which is now performed in the Department ; and, even after the native officers shall have become efficient and perfect in the new official character and language, I do not perceive how the establishments can be reduced below their present scale, with a due regard to their efficiency ; a Persian mohurrir will get through more business in a given time than either a Nagree mohurrir, or an English writer ; the Persian language being more concise and the character written with so much readiness and facility.

"If the sole consideration be the comparative expense, no change should be made, but should the Hon'ble Court consider the substitution of the English language to be a measure advisable on a higher ground — the general introduction of English literature as a means of enlarging and enlightening the minds and of improving the morals of the natives of India! would it not be prudent and expedient to make the experiment first in one or two of the Districts in the vicinity of Calcutta, Hooghly, the twenty-four Pergunnahs or Jessore? In the Western Provinces such a measure would at present excite great dissatisfaction among all classes of natives; and very justly: the evils and disadvantages would be striking and daily felt, and what benefit could they hope to derive from the introduction into all the Courts of a language of which not one native in a thousand understand a syllable. These Western Provinces will not be prepared for such a measure before the expiration of half a century.

"Would not the introduction of the English language be quite incompatible with the present system of employing native Judges to decide most cases in the first instance in original suits?

"Several disadvantages would doubtless attend the substitution of the Hindoostany language and the Nagree character : the diffuseness of the idiom, the variety of dialects, and the difficulty often experienced in reading the character readily, have been pointed out ; notwithstanding these objections, and many forcible arguments which have been advanced in favour of the Persian language as the medium for the transaction of judicial business, the evils of conducting all Law Proceedings in a language with which a great majority of the people are unacquainted, are so striking and numerous, and the benefits to be derived from the introduction of the vernacular tongue of the country, so self-evident, that I am an Advocate for the change.

"The result of the experiment now making in the Saugor Territory will materially aid the Government in forming a correct judgment."*

The 23rd July, 1836.

* Jud. Cons. (Civil), 29 Nov. 1836, N c. 8.

In forwarding the above letter to the Government of India, the Lt.-Governor of the North-Western Province differed from the view of the Sudder Courts in favouring the substitution of the Hindoostanee for the Persian language in their proceedings. The Secretary writes thus on the 25th August, 1836 :

"With reference to Paragraph 23rd of the Despatch from the Hon'ble the Court of Directors dated the 26th June 1835, received with your letter No. 168 of the 9th November last, I am directed to transmit to you for the purpose of being submitted to the Right Hon'ble the Governor General of India in Council, the accompanying letter with its enclosures in original, from the Offg. Register of the Sudder Dewanny and Nizamut Adawlut dated the 29th ultimo.

"The Lieutenant Governor concurs in the opinion recorded by Mr. Ewer to the effect that, it is desirable that the language of the people should if practicable, be that of the business of the Courts, and that at least, an endeavour ought to be made to introduce it.

"Many of the Local Officers are favourable to the immediate substitution of the Hindoostanee in the Persian character, and they believe that it may be introduced without additional expense. The Lieutenant Governor therefore proposes to authorize all such officers to substitute the Hindoostanee for the Persian in their Proceedings, to such extent, and in such manner, as they may find it practicable and discreet, so as to enable them at the same time, to preserve regularity and dispatch in business and record."*

In approving the above proposals, the Secretary to the Government of India writes on the 10th October, 1836, thus :

"I am directed to acknowledge the receipt of your letter dated the 25th August last with its Enclosure, and in reply to request that you will convey to the Hon'ble the Lt.-Governor of the N. W. P. the approval of the Governor General of India in Council, to his proposals to authorise such of the local officers as are favourable to the measure, to substitute the Hindoostanee for the Persian language in their proceedings to such extent and in such manner as they may find it practicable and discreet, so as to enable them at the same time to preserve regularity and dispatch in business and record.

"I am desired however to suggest for the consideration of the Hon'ble the Lieut.-Governor that those instructions be issued subject to this qualification that, in acting upon them, the Local Officers do not contravene existing Regulations.

"The original Enclosures of your letter are retained in order that the subject may be brought to the immediate notice of the Hon'ble the Court of Directors."†

Turning now to the sentiments of the Judges of the Sudder Dewanny Adawlut at Fort William, Bengal, we find that they were also not in favour of the discontinuance of Persian as the language of the courts. In a letter, dated the 4th March, 1837, the Registrar of the Court writes to the Secretary to Government of Bengal in the Judicial Department thus :

"In continuation of my letter to your address of the 5th August last, I am directed by the Court to forward for submission to Government a copy of one under date the 9th January (received on the 9th ultimo) from G. J. Morris, Judge of the Patna City Court, containing the opinion of that officer on the discontinuance of Persian as the language of the Courts.

"Mr. Morris, it will be seen, does not advocate any change ; and in the absence of any apparent necessity or prospective advantage demanding or inviting it, the Court entirely concur with him.

* Jud. Cons. (Civil), 29 Nov., 1836, No. 8.

† *Ibid.*

"The Court have only further to observe, that independently of the diversity of dialect which they represented in their letter of the 5th August to prevail in Bengal, the language of the Behar portion of their jurisdiction being a totally distinct one, would render another distinct Amlah or considerable portion of the Amlah, capable of reading and writing Hindustani in whatever character the proceedings might be recorded, a necessary addition to their establishment. If recorded in more than one character, at the option of the several district functionaries, then more than one additional set of clerks would be required, and the expense and general confusion be increased accordingly."

Encls.

Mr. Morris' Letter :

"I have the honor to acknowledge the receipt of your letter of the 24th December 1835, calling for an opinion, regarding the discontinuance of the Persian as the language of the Courts--and further, what language it would be desirable to substitute in its room.

"I beg the Court will pardon the long but almost unavoidable delay that has occurred in furnishing this reply--I now proceed to state briefly my sentiments on the subject under discussion

"I have always held it to be very desirable that depositions should be taken in the vernacular dialect, whatever may be, in order that persons unacquainted with Persian may on hearing their depositions read over have an opportunity of correcting any inaccuracy or error the writer may have fallen into. I have found great advantage to result from this practice, particularly in cases tried at the sessions, in which Court it has been resorted to for the last two years-- but the necessity of making translates in Persian to accompany the *roodad* in cases referred to the Nizamut Adawlut is a great additional labour to the Amlah and might perhaps be dispensed with.

"I am not however prepared to go the length of recommending that the language of record should undergo such a sudden and complete change as that contemplated. In the first place I do not think except probably in the case of the Bengallee language that an adequate substitute could be provided for Persian, and although this is the last point proposed for consideration it is in truth the first in the order of enquiry, for unless we are prepared to shew that another language possesses greater or equal advantages than the one now in use we should be no gainers by an exchange.

"If the Persian were to be done away with to-morrow in these provinces, we should have to make our choice between the Oordoo or Hindustani in the Persian character and the Hindewee in the Devanagari or the Kaithee character. As to the former, we might for all practical purposes, keep up the Persian as the language of record, for in drawing up the Minute of proceeding, the technical modes of expression and the phraseology to be adopted almost necessarily will have to follow the Persian idiom, so that the only gain by the change introduced will be a difference in the inflections, and the making sentences terminate with a Hindustani verb instead of with a Persian. On the other hand if the Hindewee were to be adopted in the Nagree character, the business of the Courts would have to remain at a standstill until it was acquired. The Devanagari character is almost unknown except to Pundits and those who have studied it in printed books; and the common kaithee it is well known is so irregularly written that take the writing of any number of Hindewee scribes at random, you shall rarely find two hands agree, and the difficulty of decyphering it is in proportion to its uncertainty. This objection doubtless might be overcome by dint of practice which would have the effect of introducing a fixed written character--but what then? It will still have to borrow largely from the Persian, Hindoostanee and English for vocables to express a variety of meanings and to fill up the conventional terms now in common use. The Hindewee is, compared with the Persian, poor and cramped and does not possess like the Bengali the power of creating upon fixed principles nouns and compound words at pleasure. In adopting the Hindewee therefore the first thing to be done would be to transplant a whole vocabulary of foreign terms and phrases adopted to the practice and usages of our courts into the new medium of communication, and this is what has already been done in the provinces in the Nerbudda.

"It is hardly going too far to assert that the people have become attached from long use to the Persian as the language of business--there is no occasion to shut our eyes to the advantages which it assuredly possesses merely because it is thought an anomalous thing to administer the affairs of the country in a language foreign to the people at large.

If the great body of suitors and others whom business carries to our courts and Revenue Cutcherries, have become habituated to that foreign language and have not hitherto found it a serious hindrance, it surely does not behove us by putting words in their mouths to imagine difficulties which they never dreamed of, and to discard what has hitherto been found such a convenient vehicle of conducting public business in a country where such a variety of spoken dialects prevail. I forbear to speak more at large of the facilities which it affords for carrying on public business from the rapidity with which it is written, compression of space, and flexibility in expression as it is only those unacquainted practically with these advantageous points who would undervalue its usefulness.

"What advantages are to be gained on the score of expence by the abolition of Persian, I am at a loss to imagine—surely the getting rid of two or three mohurrirs in each public office will be the very outside of the gain to be expected under this head. On the other hand in having to deal with such a crabbed and impracticable written character as the Nagree or Kaithi we must throw into the opposite scale the increased labour and loss of time which must necessarily be incurred in getting through, with the means and instruments now available, the ordinary business of the Courts.

"In conclusion, if one of the two vernacular Tongues must be adopted to the exclusion of Persian, we ought, upon the principle of studying the convenience of the larger body of the people to give the preference to the Hindustanee. It would have this further advantage over the Hindustani that it would lead more effectively both by change of character and of style to the entire obliteration of the Persian, and to the infusion of a larger admixture of English terms, which if we cease to borrow from the Persian must necessarily flow in to supply its place."*

However, the final blow to the continuance of Persian as court language was dealt by the passing of Act No. XXIX of 1837 on the 20th November, which reads as follows :

"I. It is hereby enacted, that from the First day of December 1837, it shall be lawful for the Governor General of India in Council, by an Order in Council, to dispense, either generally, or within such local limits as may to him seem meet, with any provision of any Regulation of the Bengal Code which enjoins the use of the Persian language in any Judicial proceeding, or in any proceeding relating to the Revenue, and to prescribe the language and character to be used in such proceedings.

"II. And it is hereby enacted, that from the said day it shall be lawful for the said Governor General of India in Council, by an Order in Council, to delegate all or any of the powers given to him by this Act, to any Subordinate Authority, under such restrictions as may to the said Governor General of India in Council seem meet."†

In conformity with the latter provision of the above Act the power being delegated by the Central Government, the Deputy Governor of Bengal adopted the following resolution on the subject on the 23rd January, 1838 :

"The President of the Council of India in Council have been pleased, on the 4th ultimo, in conformity with section 2 Act No. XXIX of 1837 to delegate to the Deputy Governor of Bengal all the powers given to the Governor General in Council by that Act, the Deputy Governor has resolved that in the Districts comprised in the Bengal Division of the Presidency of Fort William, the vernacular language of those Districts shall be substituted for the Persian in Judicial Proceedings and in Proceedings relating to the Revenue and that the period of twelve months from the 1st instant shall be allowed for effecting the substitution.

"His Honor is sensible that this great and salutary reform must be introduced with caution, involving as it does the complete subversion of an old and deeply rooted system. He therefore vests the various heads of Departments with a discretionary power to introduce it into their several offices and those respectively subordinate to them, by such degrees as they may think judicious, only prescribing that it shall be completely carried into effect within the period abovementioned.

* Jud. Cons. (Civil), 21 March, 1837, No. 26.

† Jud. Cons. (Civil), 27 March, 1838, No. 6.

"For His Honor's information, a report of the progress made in the introduction of this measure will be required on the 1st July next and again on the 1st January 1839.

"Ordered, that a copy of the above Resolution be transmitted to the General Department for the issue of instructions to the above effect in respect to the offices subject to that Department."*

By order of the authorities the Sudder Dewanny Adawlut at Fort William issued a circular letter on the 9th February, 1838, to the several Civil and Criminal authorities under their jurisdiction directing them to take immediate measures for substituting the vernacular languages of their respective districts for Persian in conducting the proceedings of their courts, as also to communicate the above orders to the several subordinate courts under them to take similar measures, and to submit by the 1st July next a report of the progress made in carrying into effect the above instructions to be laid before Government.

It is interesting now to note the progress made in the substitution of the vernacular languages for Persian, and the important sidelight it throws, as we have said, on the superiority of the Persian over the vernacular languages in many important respects, both in character and diction. Soon after the above order was made, we find that some of the Zillah Judges and others of Tirhoot, etc., communicating their difficulties about introducing the use of pure Hindi or Nagree character in recording the proceedings of the courts, from the known difficulty of deciphering the Nagree written character. The Zillah Judge of Tirhoot, in reply to an enquiry from the Sudder Dewanny Adawlut, writes on the matter on the 12th April, 1838, thus :

"I have the honor to state that the dialects prevailing in this district are three—Tuhootan which prevails to the North East, Nagree or Hudee and Reikast or Oordoo. The characters used are Nagree and Persian, and in my opinion, of Oordoo dialect and Persian character adapted for Court proceedings; for very few understand the first and no two people hardly write the same in the Nagree character as to be easily deciphered by his next neighbour; and the Nagree character moreover is cramped and stiff, whereas the Oordoo Persian character is free, soon written and more easily deciphered."†

In reply to the above, the authorities of the Sudder Dewanny Adawlut sanctioned under the circumstances the use of the Oordoo in the Persian character as the language of record.

Some time after this the Zillah Judge of Dacca, in Eastern Bengal, forwarded a petition to the Secretary to the Government of Bengal on the 8th March, 1839, from 481 inhabitants of the Dacca District, of whom 199 were Hindus, urging the continuance of the Persian language in conducting public business, which is very enlightening on the matter. The following is an abstract of the contents of the petition :

"That for a long period the use of Persian has existed. It is now ordered that Bengally should be used, but from this much difficulty will arise—some of which difficulties are mentioned below.

"1. The idiom of one district does not correspond with that used in another, and is consequently not understood elsewhere. The letters used in Bengallee, also differ in different places. It is not only difficult for a person to read anything written but even the writer who wrote it, cannot easily read his own writings. Business is therefore impeded.

* Jud. Cons. (Civil), 6 March, 1838, No. 15.

† Jud. Cons. (Civil), 29 May, 1838, No. 34.

"2. If Robecarries etc. are written in the current language of each place, they will be very lengthy—and not easily understood. The Amlah according to the late orders, write Robecarries introducing Sanscrit expressions, so that the parties concerned do not understand them until translated. It is the object of Government that the parties should easily comprehend what may be written but if a translation is required this is not obtained.

"3. What might be written in one line in Persian, requires about ten in Bengallee and if pains is taken to render what is to be expressed shorter, the meaning is not to be made out. Hence what advantage is obtained?

"4. You cannot at a glance see the meaning but must read Bengallee letter by letter. Even the writer cannot give the subject matter written above, when he has finished writing, without reading all over. If the reader is asked, where such a particular subject is mentioned, he cannot tell you, without looking over again from the beginning. To remedy this inconvenience, a summary of the contents is written in Persian, on the margin of Bengallee papers.

"5. Records have not been kept in Bengallee, under any Government, and though a person may labour to obtain proper expressions to bring into use now, still from this cause there will be objections brought against these expressions. The correctness of which objections a Judge not learned in the language or the common people will not be able to determine. Moreover there are expressions (long obsolete) which even a Pundit would not understand. The particular letters to be used is also a difficulty. From this cause injury arises.

"6. From the crabbed style in which Bengallee is written it cannot be read off with the facility with which Persian can—and cannot for the same reason be written quickly. Great delay is therefore caused.

"7. A Robecarree or Roedad which might be finished in one hour in Persian, would with difficulty be completed in a day—a translation from Bengallee into Persian will be much shortened but the reverse will be the case in a translation from Persian into Bengallee, and much paper will be used.

"1. The benefits from the use of Persian are—that it is used over a very large extent of country and is the same in all parts. The letters and the subject written easily understood. To reject this for Bengallee cannot be considered any good.

"2. The clearness of expressions in Persian cannot be reached in the Bengallee language. The first may also be written in various styles, viz. with care and clearly or in a careless and off-hand manner.

"3. The Records of Government have been kept in Persian, with brevity and with the consumption of but little paper, but nothing but inconvenience will arise from the use of Bengallee.

"4. Decrees Roedads etc. can be written out as well as could be wished in Persian.

"5. Papers on all subjects can be prepared in a satisfactory manner in a small compass, without detriment to the case, as much is expressed in Persian in a few words.

"6. Many gentlemen understand Persian well, and people of all classes can understand it when read, as it is of such general use, and sufficient for common purposes, may be learnt in a short time.

"7. From one to ten sheets of Persian can be written in so short a time, that Robecarries in many important cases, can be written at the time of passing the order, in presence of the Judge, but this cannot be done in Bengallee.

"8. All persons whether Hindoos or Mussulmen wish the language to be still continued, and are sorry to hear that it is to be abolished. From this no benefit can arise to Government and it is likely that detriment will ensue from the use of Bengallee."*

The above representation, it seems, was not without effect. In his communication, dated the 19th April, 1839, the Registrar of the Sudder Dewanny Adawlut of Bengal informs the Secretary to the Government of Bengal that the Court have qualified the terms which they formerly used on the subject. The letter says :

"I am directed by the Court to acknowledge the receipt of your letters Nos. 597 and 606, both of the 26th ultimo, and to forward a copy of the Resolutions which they purpose, with His Honor the Deputy Governor's sanction, to circulate among the subordinate Civil and Criminal authorities for their information and guidance.

"His Honour will observe, on referring to the Resolution that they have qualified the terms which they formerly used, so as to obviate any practical inconvenience which might arise from a general declaration of the right of parties to use any language which they might prefer in their petitions and pleadings."

"Resolution of the Presidency Court of Sudder Dewanny and Nizamut Adawlut under date the 19th April 1839.—

"Read the Resolutions of the Hon'ble the Deputy Governor of Bengal, under date the 26th ultimo, on the progress made in introducing the vernacular languages in the Proceedings in the Revenue and Judicial Departments.

"The Court resolve, with the sanction of His Honor the Deputy Governor, that the Oordoo language shall in future be the language of record in all proceedings and orders in the Sudder Dewanny and Nizamut Adawlut, at the Presidency and that the same shall be written in the Persian character.

"2. The Proceedings and papers in all civil cases transmitted to this Court, which may be written either in the Persian, Oordoo, or Bengallee language, shall be unaccompanied by translations; but in criminal trials referred to the Nizamut Adawlut, with exception to trials for the crime of Thuggee, all papers which may not be drawn up in the Persian or Oordoo languages shall be accompanied by translations in the latter.

"3. All papers in the Mogh, Orissa and other dialects shall be accompanied by Oordoo translations.

"4. The officers of this Court shall be allowed a period of one year from the date to qualify themselves in the Oordoo and Bengallee languages.

"5. The authorities of the district in which the Oordoo language is current shall be required to take measures for introducing the use of the Nagri character in writing the language; and to report on the 1st January next the progress which has been made in that respect.

"6. In the districts in which either the Oordoo or the Bengallee is the current language, parties are to be allowed, all civil and criminal courts, to present all petitions and pleadings in any language they think most suitable to their purpose; but any documents so presented which may not be written either in the Persian, Oordoo, or Bengallee shall be accompanied by translations in one of these three languages. The same rules be applicable to Futwas and Bowastahs required from the Law officers.

"7. The authorities in the Bengal districts shall correspond with each other in the vernacular language, and employ the Oordoo in their correspondence with the Courts of other Districts. The same rule shall be observed *mutatis mutandis*, in Cuttack and the other provinces subject to the jurisdiction of this court.

"8. The authorities of those Districts in which the Amlah have not yet sufficiently qualified themselves in the vernacular languages, are authorized to grant them a reasonable time for acquiring proficiency in the same."*

* Jud. Cons. (Civil), 7 May, 1839, No. 4.

The above Resolution was circularised to the several Civil and Criminal authorities under the jurisdiction of the Sudder Dewanny Adawlut at Fort William on the 5th July 1839.

On the other side, the Government of India was the recipient of a petition in Persian on the 9th September 1839, from some of the Zemin-dars, Vakeels and Muktears of Tirhoot, remonstrating against the introduction of the Nagree character in the proceedings of Courts. The following is an abstract translation of the same :

"State that as the British authorities have determined on introducing the Nagree letters in Courts, they beg leave to offer the following objections to it.

"They find no advantage in it at all but only inconvenience, for it is calculated to affect as well the performance of the duties of the Government as the interests of its subjects.

"As a sentiment expressed in Persian, cannot be set forth in Nagree on less than tenfold paper, the ordinary persons are of opinion that more stamp paper are to be required and thereby the use of the Nagree character will contribute to the profit of the Government, but they are quite mistaken on this point, for the Government never likes to reap such advantages at the sacrifice of the interests of its subjects which it always endeavours to promote, besides this, when the papers are thus used tenfold, the tenfold expenses will be incurred by the Government in paying servants and furnishing stationery.

"A plaintiff who could obtain his right in a year, will not succeed even in ten years—Great delay will attend the discharge of the revenue affairs of the Government.

"The Persian records of the Government for seventy years and the documents of krores of rupees for hundreds of years now in possession of its subjects, will be of no service, for in process of time no person will be found conversant with the Persian language, and a case which has connection with those papers, will not be easily decided. A person who understands the Hindwee language, knows that the Hindwee letters are distinctly written and that sometimes seven or eight letters form a word. As the Hindwee characters are distinctly used, it is with great difficulty that the preceding word can be distinguished from the following at the time of perusal, more time is spent, meaning is affected and the hearer gets confused, moreover where the writer himself cannot make it out, how is it possible then that others will comprehend it?

"The Nagree characters of every zilla, even of every pergunnah—especially in the neighbourhood of Behar are of different forms as for instance the letters of Mugh, Bhojepore, Sarun and Tirhoot differ from each other. When a letter of a place is made out by guess in another, it is not probable that the real meaning of the writer should be comprehended. The use of the letters of one form in every court will facilitate the transaction of the affairs of the Government. In case the Nagree characters which are of various forms, should be used in courts, persons acquainted with these forms ought to be appointed Amlahs, in order that when the orders etc. of one zilla Court are received in another, they may be understood in the latter. The persons who are acquainted with Nagree letters, do not know the regulations and rules of the Court. Those who hold high situations under the Government are at a loss to conceive how the decisions of cases connected with the Mahomedan law passed by Mooftees, Quazees etc. are to be expressed in Nagree.

"Under the above circumstances an application, if made by any local British Functionary at the suggestion of any ignorant person for the use of the Nagree character, cannot be held as sufficient ground for the discontinuance of the Persian language.

"All people of this place whether Hindoo or Mahomedan heard this news with great disappointment.

"In conclusion pray that the use of the Persian language may be continued as formerly."*

* Jud. Cons. (Civil), 18 Oct., 1839, No. 17.

In forwarding the above petition, the authorities of the Government of India, in a letter dated the 26th September 1839, directed the Bengal Provincial Government to pass such orders as they deemed deserving on the above representation. And it seems that in compliance therewith the Sudder Dewanny Adawlut at Fort William, at the suggestion of the Deputy Governor of Bengal, issued circular letters on the 1st November, 1839, to the several Civil and Sessions Judges, Magistrates and Joint Magistrates in the Behar Provinces and to the Governor General's Agent at Hazareebagh, informing them for their guidance the desirability of adopting some modification in their general provision for the use of Nagree character contained in their resolution of the 5th July last. The letter reads as follows :

"The instructions contained in paragraph 5 of the Court's Resolutions of the 5th July last, regarding the use of the Nagree character in writing the Oordoo language, being general, and it being material that that measure should be carried into effect without obstruction to public business, I am directed by the Court to request your particular attention to the necessity of introducing the change in the most gradual and careful manner.

"It will be proper for you, the Court observe, before taking any decisive steps to make enquiries on the subject, as to the mode in which the wishes of the Government, to render all public proceedings intelligible to the people, may be fulfilled consistently with the disposal of the business of your Court with due regularity and expedition. It will be expedient also that you put yourself in communication with the other authorities of the District both Judicial and revenue, in order to the adoption of a uniform system in all the branches of the public service.

"The Court request you will postpone the report which was formerly required, to the 1st March next."*

Beginning thus slowly and cautiously in their bold step of abolishing Persian as court language, the authorities of the East India Company constantly accelerated the pace till the object was fully accomplished. "Had we hastened," says Sir William Hunter, "by a single decade our formal assumption of the sovereignty, we should have been landed in a Muhammadan rising infinitely more serious than the mutinies of 1857... The admirable moderation of the East India Company's servants, and their determination to let the Muhammadan Power expire by slow natural decay, without hastening its death a single moment, averted this danger. India passed from a Country of Islam into a Country of the Enemy by absolutely imperceptible gradations.... We got rid of the subordinate Muhammadan Governors long before we touched the nominal supremacy of the Muhammadan Emperors. Long after that nominal supremacy had become a farce, and indeed up to 1835, our coinage still issued in his name. Even after we thus ventured to impress the British Sovereign's effigy on our coin, we maintained much of the Muhammadan procedure along with the Muhammadan Court language. These in their turn slowly disappeared. But it was not till 1864 that we took the bold step, and in my opinion the unwise step, of doing away with the Muhammadan Law Officers by an Act of the Legislature. This Law put the last touch to the edifice of the new Empire of India as a country of the Enemy, the rebuilding of which had been wisely spread over exactly one hundred years (1765 to 1864)."[†] He observes again :

* Jud. Cons. (Civil), 12 Dec., 1839, No. 1.

† *The Indian Muslims*, (Comrade Publishers, Calcutta, 1945), pp. 130-31.

"The third source of their greatness was their monopoly of Judicial, Political, or in brief, Civil Employ... Yet for some time after the country passed under our care, the Musalmans retained all the functions of Government in their own hands... The Code of Islam remained the law of the land, and the whole ministerial and subordinate offices of Government continued the property of the Musalmans. They alone could speak the official language, and they alone could read the official records written in the Persian current hand. The Cornwallis Code broke this monopoly less violently in the Judicial than in the Revenue departments, but for the first fifty years of the Company's Rule the Musalmans had the lion's share of State patronage. During its second half century of power the tide turned, at first slowly, but with a constantly accelerating pace, as the imperative duty of conducting public business in the vernacular of the people, and not in the foreign *patois* of its former Muhammadan conquerors, became recognised. Then the Hindus poured into, and have since completely filled every grade of official life."* The fall of the Moslems thus from their position of influence and power has been happily recognised by Sir William as one of the wrongs of the Muhammadans under British rule, which, though due to the blunder of the Indian Government, took the authorities quite a long time to gauge till they were forced to do so through great Muhammadan disaffection. And though some meliorating steps commenced being taken since the time, yet lot was deemed to remain to be adopted to bring them to the desired level or position.

* *The Indian Musalmans*, (Comrade Publishers, Calcutta, 1945), pp. 157-58.

BOOK REVIEWS

Kenopanishad-Bhashya, by Sri Rangaramanuja—Critically edited by Dr. C. K. Varadachari and Pandit D. T. Tatacharya. Sri Venkatesvara Oriental Series No. 8. Published by Sri Venkatesvara Oriental Institute, Tirupati, 1945. Demy octavo. Pp. x, 22, 18. Price Rs. 2.

THE *Kenopanishad* is a short and sweet but philosophically highly important text, belonging to the earliest period of the Upaniṣads. This edition contains a neatly printed text with *Bhāṣya* of Śrī Raṅgarāmānuja (born about the middle of the 16th C. A. D.) who belonged to the Viśiṣṭādvaita school of Śrī Rāmānujācārya. The *cintanā* on the *Bhāṣya*, in Sanskrit is a special feature of this edition and is very useful for a full and correct understanding of the *Bhāṣya* which on account of its brevity does indeed stand in need of a comprehensive exposition. It critically discusses points of grammar, readings of the *Bhāṣya* and suggests emendations. The translation is well-made and literal, and occasionally contains explanatory notes.

The Introduction deals with the author and his works, gives a summary of the text and ably evaluates the philosophical teachings of the Upaniṣad and ends with an account of the six earlier editions on which the present one is based. One would have much liked it had this edition brought out by a Research Institute been a critical one based on independent and original manuscripts.

—N. A. GORE

Dr. C. Kunhan Raja Presentation Volume. Published by the Adyar Library, for the Dr. C. Kunhan Raja Presentation Volume Committee, Madras, 1946.

THIS is a Volume of Indological Studies published by the Dr. C. Kunhan Raja Presentation Volume Committee, Madras and presented to the erudite and distinguished Indian Savant Dr. C. Kunhan Raja as a modest token of appreciation of his contribution to the oriental studies during the last twenty-five years by his friends, students, colleagues and contemporaries devoted to oriental studies and research. Dr. C. Kunhan Raja has earned for himself an almost unique and enviable place in the field of Indological studies by his noteworthy contributions in the form of books and research papers touching many branches of oriental studies. The present volume is a clear index of the same.

The volume opens with a brief, biographical sketch of the learned Doctor with a list of his publications—books and papers—as far as they could be ascertained, given in the appendix to this biographical note. The list gives one an idea of the enormous work that the doctor has put in indefatigably during the last twenty-five years. Then follow one after another Research Papers—more than fifty in number—contributed by Scholars of repute and learning not only from almost all over this country but from foreign lands as well. These articles embrace many aspects of Indological Studies, treat a variety of subjects and show the labour and learning of their authors. They are, as a matter of fact, a tribute paid to a great scholar by the Community of Pundits from the east as well as the west.

The idea of presenting such a volume to Dr. C. Kunhan Raja was conceived by his friends and admirers in August 1944. The members of the Committee deserve our congratulations for publishing such a big volume covering more than 500 pages in such a short time despite the many difficulties it had to face in these abnormal times.

The volume deserves to be read by every student of oriental studies.

—H. R. KARNIK

Sri Siddhahemachandraśabdānuśāsanam (Part I), by Sri Hemachandrasūri, with the Author's own *Tattvapraṇāśikā* and Chandrasāgaragani's *Ānandabodhini*--Edited by Pannysa-pravara Sri Chandrasāgaragani. Published by J. P. Rupchand, 25-27, Dhanji Street, Bombay, 1946. Price Rs. 30.

THIS is a beautifully printed and carefully prepared edition of a portion of Hemacandra's famous grammar of the Sanskrit and Prakrit languages, called the Siddhahema. This Part contains the 1st Adhyaya and two quarters of the second (Sanjna, Sandhi, Nama and Karaka Prakaranas only) and is accompanied by the author's own commentary called *Tattvapraṇāśikā* as also by Chandrasāgaragani's commentary called *Ānandabodhini*. The work is very well edited by Chandrasāgaragani himself who is a living author of great erudition.

The great Vyākaraṇa of Hemacandra which has successfully sought to improve upon all the then existing works on grammar, was composed sometime about Śaivāt 1195. Hemacandra was a great and versatile writer who wrote authoritative treatises on almost all branches of Sanskrit literature. He was the first great writer who gave equal importance to the Prakrit languages by the side of Sanskrit, the queen of all the ancient Indian languages, in his treatises on grammar and metre.

The new commentary composed by the editor himself is very useful especially for beginners. It carefully explains the Sūtras as also the words of the *Tattvapraṇāśikā*, only rarely introducing independent discussions, which are not suggested in the *Tattvapraṇāśikā*. The utility of the book is still more enhanced by the detailed list of Contents given at the beginning and the 13 *Parīkṣitas* which are added at the end, the last of which gives a full list of doubts raised and answered in the Sūtras and the two commentaries.

—H. D. VELANKAR

Life of Dayanand Saraswati, by Har Bilas Sarla.

RAI SAHEB HAR BILAS SARDA is to be congratulated on bringing out this first complete and well documented biography of the leader of Vedic revival in India. In trying to emphasize the importance of the Vedic religion and the work of Swami Dayanand, the author has sometimes gone beyond the limits of fair criticism of other faiths and other religious leaders. Except this drawback the book maintains a very high level of treatment of an undoubtedly great subject.

The book is divided into an introduction and four parts and each part deals with some aspect of the life and teaching of the great sage. In dealing with each section the author has shown a commendable thoroughness in sifting all available material and has moulded it into shape with his mature scholarship.

—P. M. J.

The Peace of the Augustans, by George Saintsbury, with an Introduction by Sir Herbert Grierson. The World's Classics, Oxford University Press, 1946.

THE *Peace of the Augustans*, now included in the famous series, *The World's Classics*, is a reprint of a book that first appeared in 1916, in the eventful days of World War I. The alternative title of the book (*A Survey of Eighteenth Century Literature as a place of Rest and Refreshment*) was a challenge to the twentieth century which affected to look down on the eighteenth century as a century of prose and little things, mechanical verse and vapid thinking, shallow sentimentalism and Tory self-complacency. Saintsbury turned from his weary war-worn sensation-loving contemporaries to look at their eighteenth century forbears with longing and affection, and *The Peace of the Augustans*, because it is written to expound a thesis, often becomes an exercise in special pleading. Conscious of the objection that might be raised against Swift and Pope, the greatest of the Augustans, being termed as purveyors of rest and refreshment he twists his argument so as to surmount the inevitable caveat. He says: "It may well seem to be either an idle paradox or a wanton absurdity to speak of 'the Peace of the Augustans' in connection with their greatest man, Jonathan Swift, the most hopeless misanthropist and almost the miserrimus of literary history," and gives a reply that there is peace or Refreshment and Rest in Swift's writings because "in Swift's actual works there is never any moaning or raving; there is as little of the inky cloak and the skull in hand as of the desperado's yellow boots and fist shaken at Heaven." This means that a writer may utter blasphemies and make the most revolting proposals regarding men, women and children, but as long as he refrains from making a fuss or passionate speeches like Ham-

let he should be numbered among the comforters and consolers of mankind. To Saintsbury, *manner* seems to be everything and *matter* almost nothing. His opinion is: "You can, to some extent, consider manner apart from matter; you can never entirely reverse the operation with any result satisfactory to literature." The *manner* of Pope was, however, by no means quiet and gentlemanly, but Saintsbury comes to the rescue of Pope with the explanation that "though he (Pope) enjoyed little rest or refreshment himself, he has provided much for others." What shall be then said of Wordsworth whose merit was acclaimed by a twentieth century poet in the ringing words: "Thou hadst for weary feet the gift of rest," and "Men turned to thee and found not blast and blaze . . . but peace on earth?" Let the readers of Pope and Wordsworth decide for themselves which of these two poets really provides "a place of Rest and Refreshment."

Saintsbury's tone is challenging in several places, and not without reason. For instance, he cannot bear the deprecatory remarks made by Macaulay against Grub Street and Grub Street authors (especially Johnson) and joins issue with him to convince his readers that there was nothing particularly pitiable in the condition of the Grub Street authors. Johnson is excluded by him from the purview of Grub Street altogether. *The Peace of the Augustans* is called by the author "the usual *History of Eighteenth Century Literature* with a difference" and that "difference" is apparent when he assigns to the forgotten author of the *Night Thoughts* two thirds of the space reserved for the author of *The Rape of the Lock* and *The Dunciad*. The great merit of *The Peace of the Augustans* is the astonishing condensation of a mass of facts stupendous in their range and variety and the masterly survey of this material in nine brief chapters. The great drawback of the book—for the general reader—is the irritating allusiveness on the part of the author which interferes with the reader's enjoyment of a good substantial fare. Macaulay's allusiveness has a charm of its own and stimulates the reader to hunt out references for himself; Saintsbury's allusiveness leaves the average reader crushed with a sense of impotence and ignorance, and provides no incentive for him to trace those allusions patiently and firmly.

The chapter on Johnson is the most readable in the book, and next after it the chapter entitled *The New Paradise of the Novel*. In both these chapters the author is on much firmer and safer ground than in other chapters, particularly those that have anything to do with the Romantics. Considering all things, there is hardly any other book so replete with information about Eighteenth Century Literature as *The Peace of the Augustans*, and certainly there is none more authoritative.

—L. H. AJWANI

John Donne (Poetry and Prose), with an Introduction and Notes, by H. W. Garrod. Oxford University Press, 1946.

WITH the possible exception of Blake, there is no other English poet to rival John Donne in the tremendous advance made in his reputation and appeal to the general reader in the present century. When it is remembered that Rupert Brooke and many other modern poets are the direct disciples of John Donne we might regard the vogue of Donne or the revival of interest in his poems and sermons as one of the notable happenings in the literary history of our times.

The life of Donne was eventful and stirring even for the adventurous age in which he lived. He was a scholar, courtier, warrior, lover, philosopher and divine, married a woman against her father's wishes like another poet (Robert Browning) with whom he has many points in common, but was more lucky in the end, for the irate father was not only reconciled to him at last but even settled an allowance upon him. For a philosopher he was an astonishingly shrewd man of the world, and he could win and retain the favour of a foolish and whimsical sovereign as also of a band of scholars and poets. He would not, however, bend his knee to the world and utter platitudes and smooth nonsenses; he delighted in shocking his contemporaries (and confusing posterity?) by mixing heaven, earth and hell, love, death and soul, delicious phrases and fantastic images, musical verse and cacophonous and tortuous expression. He maintained his thought, however, at a very high level whether he was writing poetry or delivering sermons, and paid the penalty for his lofty speculations, and "divine" imaginings, by being dubbed "metaphysical" and consigned to an almost utter neglect for hundreds of years.

But now he has come into his own, and with the growth of many *isms* and *logies* there is even an apprehension that he might be invested with divine honours, and a regular Donne cult started. Whatever the men of the seventeenth, eighteenth or

nineteenth centuries might have made of his verses and sermons, readers of the twentieth century find something startlingly modern and refreshing in passages such as the following (culled at random from the present selections) :

Now thou hast lov'd me one whole day,
To-morrow when thou leav'st, what wilt thou say?
Wilt thou then Antedate some new made vow?
Or say that now
We are not just those persons, which we were ?

Or

I can love both faire and browne,
Her whom abundance mette, and her whom want betraies,
.....
I can love her, and her, and you, and you,
I can love any, so she be not true.

Here is a higher note (about lovers) :

Here upon earth, we're kings, and none but wee
Can be such kings, nor of such subjects bee ;
Who is so safe as wee ? where none can doe
Treason to us, except one of us two.

And about Death :

Death be not proud, though some have called thee
Mighty and dreadful, for, thou art not soe,
For, those, whom thou think'st, thou dost overthrow,
Die not, poore death, nor ye, canst thou kill me.
.....
One short sleepe past, wee wake eternally,
And death shalt be no more ; death, thou shalt die.

His prose meditations are lucid and astonishingly like those we find in the authors of our age. For instance : "Every woman is a *science* ; for he that plods upon a woman all his life long, shall at length finde himself short of the knowledge of her.... And what reason is there to clog any woman with one Man, be he never so singular ?" and "When I consider the past, and present, and future state of this body, in this world, I am able to conceive, able to expresse the worst that can befall it in nature, and the worst that can be inflicted upon it by man, or fortune ; But the least degree of glory that God hath prepared for that body in heaven, I am not able to expresse, not able to conceive."

Donne was not always so simple or direct in his approach to his subject or the expounding of it. His usual method is to be abstruse and employ far-fetched images and analogies. When he wants to describe a newly married pair, he says :

..... Here lies a shee Sunne, and a hee Moone here,
..... She gives the best light to his spheare,
..... Or each is both, and all, and so
..... They unto one another nothing owe.

When he writes on *The Second Anniversary* of the death of a girl he never saw, he celebrates her as under :

Immortall Maid, who though thou would'st refuse
The name of Mother, be unto my Muse
A Father, since her chaste Ambition is,
Yearly to bring forth such a child as this.

The Indian reader will perhaps revel in Donne's "metaphysical" speculations and utterances more than even the English reader, and titles such as "The Extasie," "The Canonization," "A Lecture upon the shadow," will make an instant appeal to him. While other Elizabethan poets are prescribed again and again for students in Indian schools and colleges, Donne has been neglected, perhaps also for want of a suitable anthology from his writings. The present selections, with Walton's life and Hazlitt's critical remarks (among others) prefixed to them, should make a very good reading for the Indian student,

—L. H. AJWANI

The Critique of Pure English from Caxton to Smollett: Collected by William A. Craigie. S. P. E. Tract No. LXV. Clarendon Press, Oxford, 1946. 5 sh.

THE Society for Pure English, with which are associated the names of Robert Bridges, Henry Bradley, H. W. Fowler and Otto Jespersen, has done noble work in recording the peculiarities of the English language, and to some extent directing its development. In this tract Sir William Craigie of Oxford English Dictionary fame has collected a number of passages from earlier English writers who were attempting to do, however, imperfectly, and in some cases mistakenly, what the Society for Pure English is attempting to-day, namely to prevent the English language from taking false paths, without pretending to control it or legislate for it.

The selection of passages is happy and often entertaining, since it begins with Caxton's story about eggs, and ends with Smollett's *Lismahago*. In his introduction Sir William Craigie goes back still further to William of Malmesbury in the twelfth century, who seems to have been the first to discuss the dialects of English. Caxton, however, seems to have been the first to raise the question of a standard, and he was followed in the next century by a number of writers.

Some of the writers here quoted are extremely critical of their own language, and suggest that it needs additions from other tongues, while others resent or even condemn the importation of foreign—especially Latin—words and terms. A common complaint made by Nashe, for example, in 1594, is that "our English tongue of all languages, most swarmin with the sugie money of monosyllables, which are the only scandal of it." Another quotes the opinion of strangers that it "is of itself no language at all, but the scum of many languages." The general consensus of opinion, however, appears to be that English has much to be said for it in its faculty of borrowing words and making them at home, and thus enriching itself. The treatise entitled *Vindex Anglicus; or the Perfections of the English Language Defended and Asserted*, printed in 1644, which is given in full at the end of the tract, makes this claim: "Certainly the mixture of our extractions from others, joyned with our owne monosyllables, make up such a perfect harmony: that so you may frame your speech maiestically, pleasant, delicate, or manly according to your subject, and exactly represent in ours, whatsoever grace any other Language carrieth."

Stilted and obscure language is rightly parodied by several writers, including Sydney, Wilson (1553) and Addison. It is interesting to note that even the most acute observers are seldom infallible as to which borrowings are likely to survive. Sidney, for example, condemns by burlesquing them the words *contaminate*, *plebian*, *resplendent*, *segregate*; Puttenham, though he admits their value, is doubtful of *penetrates*, *scientific*, *numerous* and *idiom*, while as late as 1678 E. Phillips includes among "affected words" which "are either to be used warily, . . . or totally to be rejected as barbarous" *autograph*, *ferocious*, *evangelize*, and *repatriation*. We are reminded of the plea for a standard not wholly that of Southern English, made in the earliest tracts of the Society, by the passage from Smollett's *Humphrey Clinker*, in which we read of Lieutenant Lismahago's "assertion, that the English language was spoken with greater propriety at Edinburgh than in London," and his affirmation that "we mumbled our speech . . . in such a manner, that a foreigner, though he understood English tolerably well, was often obliged to have a recourse to a Scotchman to explain what a native of England had said in his own language."

This tract of fifty-seven pages is a notable addition to the Society's publications.

—R. T. S. MILLAR

URDU BOOKS

Dāstān-i-Dānish, by Dr. Khalifa Abdul Hakim. Anjuman-i-Taraqqi-i-Urdu, Delhi.

FOR the first time in the history of the Urdu language the story of Greek philosophy has been told for the benefit and pleasure of Urdu knowing readers in a very lucid and fascinating manner by Dr. Khalifa Abdul Hakim of the Osmania University, Hyderabad. The *Dāstān-i-Dānish*, published recently will, it is hoped, rank with other works of similar nature, e.g. Durant's *Story of Philosophy* and Aga Furuqhi's *Sair-i-Hikmat dar Arupa* in Persian. Following the earlier works the author has spared no pains to present therein an account of philosophy in a clear style and has succeeded in bringing the philosophical problems within the range of an average reader's understanding. The language

generally used is chaste and flawless. Quotations from great poets like Rumi, Sâdi, Hâfiz, Ghâlib and Iqbâl have added to the charm of the book, which ends with an account of Saint Augustine. It may be presumed that this work will be followed by other volumes giving an account of the subsequent development of philosophy down to our own times.

We would, however, like to point out that the book is without any introduction or index. If a few foot-notes had been added here and there the readers would have found it easier to understand the names of certain persons and places mentioned in the book.

—N. A. NADVI

Fann-i-Sahafat, by Rahm Ali al-Hashimi.

IT is more than a century ago that the Urdu newspapers were first published in India. Since then Urdu journalism has continued to progress in spite of some great handicaps but one is astonished to find that during this long period not a single book was written for the benefit and guidance of those interested in journalism. Chaudhry Rahm Ali al-Hashimi, who is an experienced journalist himself, has supplied this long-felt want by giving in his *Fann-i-Sahafat* the essential qualifications of a successful journalist, and by discussing various subjects so vitally connected with journalistic career. If the useful suggestions which the author has made throughout the book are properly availed of by the journalists, Urdu journalism would be able to claim a position of equality with the highly advanced journalism of other countries. Lithograph printing has been responsible to a great extent for the backwardness of Urdu journalism. The author is emphatically of the opinion that unless this system is replaced by a better system of printing there is not much hope for improvement. He cites the examples of late Sir Sayyid Ahmad Khan and Maulana Abdul Kalam Azad as having discarded the lithograph and encouraging the Nashk type which is in use in Egypt, Iran and other Islamic countries.

The present work, though it is a first attempt of this kind in Urdu, will be very useful for the Urdu knowing readers.

—N. A. NADVI

GUJARATI BOOKS

Amarachanû Athawâ Ashrami Kelavani, by Jugatram Dave, Navjivan Prakashan Mandir, Ahmedabad, 1946. Price Rs. 4-8.

JUGATRAM DAVE, one of the well-known followers of Gandhiji, has become an expert in founding and conducting Ashramas. The life lived at these places aims at an ideal of purity, and fulfilment of domestic and civic duties, of the highest order. Jugatram Dave's contribution to this subject of national importance consists of 76 sermons or lessons, addressed to the occupants of the Ashram, and they range over all conceivable topics, from children's toys to their upbringing and education, efficacy of prayer, self improvement, and many other useful walks of life. Each lesson is full of practical advice, based on personal experience and couched in simple and popular language. Kaka Kalelkar's foreword, the foreword of a close companion in the Ashrama, is as is usual with all his contributions, informative, instructive and full of guidance.

—K. M. J.

Gita Dhwani, by K. G. Mashruwala. Navjivan Prakashan Mandir, Ahmedabad. 1946. Price 6 Annas.

THIS is the third edition of Mashruwala's work. It is a translation into Gujarati verse—*Sama Shloki* of the *Bhagvad Gita*, and in spite of difficulties, obvious and many, in the way of such a "translation," due to the extreme technicality of the philosophy of the *Gita*, Mr. Mashruwala's attempt has been a success. Every word is chosen with care and an eye to bringing out as much as possible the significance carried by it. The few verses selected by him and presented in the forefront for self meditation are the very core of the *Gita*, and are so well chosen that they would furnish a vehicle for meditation to every reader, so inclined,

—K. M. J.

Dwārākā, by Kallianrai N. Joshi. Published in the Sayāji Sāhitya Mālā as Pushpa (Flower) No. 296, by the Baroda State : Thick Card Board. Pp. 168. Illustrated. Price Re. 1-1-0 (1946).

DWARKA is said to have been founded by Krishna, and is one of the seven holy cities, a pilgrimage to which leads to *Moksha* (Salvation). Mr. Joshi has resided in this holy city for a long time as the Principal of the High School there, and utilised his leisure in collecting material for a historical work on the subject. But before publishing that big work he has thought it fit to give us an outline thereof, a sort of guide to tourists and pilgrims, who go there in large numbers. It is both informative and interesting. It gives details as to what a pilgrim is expected to do, both on his arrival and departure. The local or Tirtha Purohits, who act as guides, claim a chapter, as does the Seat (Pitha) of Shankaracharya, and his work. Dwarka being one of the four Seats (Pitha) founded by him. Romance naturally has grown up round the environments of this ancient city, and Mr. Joshi has not neglected to depict that phase of its history too. On the whole we think it is bound to become a popular book.

—K. M. J.

Loka Sāhityaman Samalochan, by the late Jhaverchand Kalidas Meghani, B.A. Published by the University of Bombay, through N. M. Tripathi & Co., Bombay 2. Cloth bound. Pp. 257. Price Rs. 2-1-0 (1946).

THE University of Bombay gets a series of lectures delivered every year, on some subject, literary or historical, connected with Gujarat by recognised scholars. The late Mr. Meghani was selected to deliver them for 1941-42. He was a scholar so far as the Folklore of Kathiawar was concerned with first class credentials. In fact, at great sacrifice, monetary and physical, he went about and visited most inaccessible places, and approached illiterate men and women and took down verses and words, recited by them with a view to preserving them. He has thus captured a large volume of this oral literature, which otherwise would have perished along with the death of those men and women who recited it. It is this literature, which he has reviewed in the five lectures he delivered in the Convocation Hall of the Bombay University in 1943. His popularity as the exponent of this branch of Literature was such that the spacious Hall was found too small to contain the large audience that flocked to hear him, and every day there was an overflow. He has traced, with the accuracy of a born scholar, (1) The history of Folklore in general and of Gujarat and Kathiawar in particular, (2) its boundaries, (3) the causes which inspired it and brought it into being, (4) its aliveness, due to devoted workers in that direction, (5) its utility and the delight it gives. Wedding songs, Lullabies, meteorological predictions find their due place in the Lectures. The publication adds a valuable book to the small collection of works on the subject in the Gujarati Literature.

—K. M. J.

LIST OF THESES

*Table showing M.Ed. and Ph.D. Graduates in Arts with the title of Theses, etc.
for the year 1946-47*

<i>Name of the Candidate</i>	<i>Title of Thesis</i>	<i>Guiding Teacher (Internal Referee)</i>	<i>Date of Result</i>
M.Ed.			
Bana, F. H. ..	History of Institutions Supported by Parsi Philanthropy and Enterprise in Education	Mr. H. V. Hampton (S. T. C.)	June 13, 1947
Kale, S. V. ..	An Investigation into the Professional and Economic Status of Graduate Teachers in Poona	Principal V. V. Kamat (Til. Col.)	May 12, 1947
Kelkar, S. V. ..	A Critical Analysis of Arithmetic Text-books Used in Marathi Primary Schools	Dr. D. V. Chikermane (Bcl. T. C.)	May 5, 1947
Narawane, V. N.	Primary Education in India —1931-41 (A Comparative Study)	Professor R. V. Parulekar (S. T. C.)	Feb. 21, 1947
Ramasesha Rao, B. N.	Pre-University Education in Mysore	Mr. M. T. Vyas (New Era School)	Nov. 7, 1946
Scolekar, U. R. ..	The reproduction Vocabulary (in Marathi) of Children who have Completed the Primary Course	Professor S. Panandikar (S. T. C.)	April 25, 1947
Sanskrit			
Ph.D.			
Devasthali, G. V.	Mimamsa—the Vakyashastra of Ancient India Based on the Mimamsa-Sutra of Jaimini and Sabarasvamin's Bhasya Thereon	Professor H. D. Velankar (W.)	Dec. 12, 1946
Garge, D. V. ..	A Critical Study of all Passages and Sections from Older Literature (Vedic and Post-Vedic) Presupposed and Discussed in the Sabara Bhasya on the Purva Mimamsa Sutras of Jaimini with a view to Assess the Contribution of Sabara and Jaimini to the Clarification of the Sacrificial Procedure Embodied Therein	Professor V. M. Apte (D. C. P. & R. I.)	March 19, 1947
Krishnamoorthy, K.	Dhvanyaloka and its Critics —Sanskrit Poetics	Independent Work ..	March 19, 1947
Shastri, H. G. ..	Data Supplied by the Sanskrit Inscriptions of the Valabhi Kingdom	Professor K. V. Abhyankar (G. C.)	June 13, 1947
Tagara, G. V. ..	Historical Grammar of Apabhramsa	Dr. S. M. Katre, (D. C. P. & R. I.)	Sept. 10, 1946
Persian			
Sadarangani, H. I.	The Persian Poets of Sind (A Critical Study dealing with the thought and work of the Representative Persian Poets of Sind through the Ages)	Dr. H. M. Garbuxani (D. J. S.)	Aug. 17, 1946

Name of the Candidate	Title of Thesis	Guiding Teacher (Internal Referee)	Date of Result
Marathi Dandekar, V. P.	Marathi Natyasrishti-Samajik Natakne	Independent Work ..	July 12, 1946
Gujerati Vakil, P. N. ..	Doubtful Authorship of some of the Works of Premanand—A Gujarati Poet of the Mediaeval Period	Professor R. V. Pathak (S. L. D.)	Feb. 20, 1947

BOOKS RECEIVED

- Adhamodharaka Sahjanandji*, by C. Mehta. Sayaji Bala Gyan Mala, Baroda.
- Agah and Other Stories, The—*, by Gertrude Murray. Hind Kitabs, Bombay. Rs. 2.
- B. B. C. Pamphlets :*
Books and Authors, No. 2.
Landmarks in American Literature, No. 3.
- Calendar of the Bishop's University*, Lennoxville, Quebec, for 1947-48.
- Christian Prayer and Approach to Christian Mysticism*, by W. Q. Lash. Hind Kitabs, Bombay.
- Destruction of Students by Their Teachers*, by Chas. W. Rankin.
- Dieya Prem Darchan*, by P. P. Bakshi. Sayaji Sahitya Mala, Baroda.
- Hindustani Kahani Sangraha*, Part I, by Girdi Raj Kishore. Navajiwan Karyalaya, Ahmedabad.
- Kagada-ni-Najare*, by Ashram-no-Vllu. Navajiwan Prakashan Mandir Ahmedabad.
- Mawri Khandhyero*, by Kaka Kalelkar and K. Mashruwalla. Navajiwan Prakashan Mandir, Ahmedabad.
- Manukanj*, by M. Trikamjee. Navajiwan Prakashan Mandir, Ahmedabad.
- Naon Daur*, by Professor L. H. Ajwani.
- Presidential Speech of Mr. B. I. Jalan*, delivered at the Annual General Meeting of the Marwari Chamber of Commerce.
- Proceedings of the University of Durham*, Philosophical Society, Nov. 1946, Vol. X, Part 5.
- Reflections and Reminiscences*, by N. Gupta. Hind Kitabs, Bombay.
- Report—*
Annual—Nagpur University, for the year ending 30th June 1946.
Annual—University of Madras, for the year 1946—Nineteenth.
Annual—Vishveshvaranand Vedic Research Institute, Lahore—Twenty-Second.
Presidents—University of Toronto, for the year ending 30th June 1946.
Progress of Education in Orissa, for the year 1943-44.
- Rubaiyat of Baba Tahir. The—*, by D. C. Datta. Translated.
- Sheni and Viharand*, by V. K. Oza. National Information and Publications, Ltd., Bombay.
- Shri Yatra-ni-Udane*, by Kaka Kalelkar. Navajiwan Karvalaya, Ahmedabad.
- Sri Suta Rakshasi Samvada Tatvam*, by Brahma A. Sankara Sastrigal.
- Three Stories*, by Humayun Kabir. Hind Kitabs, Bombay. Price Re 1-4-0
- To High Kaiias*, by Will Quinlan. Hind Kitabs, Bombay.
- University of Ceylon Review*, April 1947.
- University of Edinburgh—Address to the General Council*, by Principal Sir John Fraser, on 1st November 1946.
- Unmatt-Ganga*, by D. P. Joshi and P. N. Joshi.

ACKNOWLEDGMENTS

Akhgar
American Literary Association Bulletin
Aryan Path
Bharata Dharma
Bharatiya Vidya Patrika
Bombay Law Journal
Bombay Legislative Assembly Debates
Bombay Legislative Council Debates
Buddha Data
Bulletin de A'Alliance Francaise de Bombay
China
Dharmendrian

Educational Review
Indian Literary Review
Indian P. E. N.
New Review
Publications of the Universidade de Santo Domingo
Religions
Ruzgar-i-Nau—Persian Quarterly Magazine
Shodh Patrika
Time and Tide
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Women's Sports World

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GENERALISATION OF THE EXPANSIONS of

$$\log (1+x), (1+x)^m \text{ and } e^x$$

BY DR. G. S. MAHAJANI, M.L.C.

1° IN the March issue of this *Journal*, Dr. Ram Behari and the present writer gave the following generalised formula for the logarithmic expansion—

$$\log (1+a_1x+a_2x^2+\dots) = \frac{\Delta_1x}{1} - \frac{\Delta_2x^2}{2} + \frac{\Delta_3x^3}{3} - \dots$$

where, $\Delta_1 = a_1$, $\Delta_2 = \begin{vmatrix} a_1 & 1 \\ 2a_2 & a_1 \end{vmatrix}$, \dots

$$\Delta_3 = \begin{vmatrix} a_1 & 1 & 0 \\ 2a_2 & a_1 & 1 \\ 3a_3 & a_2 & a_1 \end{vmatrix},$$

and generally—

$$\Delta_n = \begin{vmatrix} a_1 & 1 & 0 & 0 & \dots & 0 & 0 \\ 2a_2 & a_1 & 1 & 0 & \dots & 0 & 0 \\ 3a_3 & a_2 & a_1 & 1 & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ na_n & a_{n-1} & a_{n-2} & a_{n-3} & \dots & a_2 & a_1 \end{vmatrix}.$$

.....I

Before proceeding to give the general formula for the Binomial expansion, I shall first give a proof of this result I.

Proof: Differentiating I, we get—

$$(a_1 + 2a_2x + 3a_3x^2 + \dots) = (1 + a_1x + a_2x^2 + \dots)(\Delta_1 + \Delta_2x + \Delta_3x^2 + \dots)$$

Equating the coefficients, we have—

$$\begin{aligned} a_1 &= \Delta_1 \\ 2a_2 &= a_1\Delta_1 - \Delta_2 \\ 3a_3 &= a_2\Delta_1 - a_1\Delta_2 + \Delta_3 \\ 4a_4 &= a_3\Delta_1 - a_2\Delta_2 + a_1\Delta_3 - \Delta_4 \\ &\dots \dots \dots \\ na_n &= a_{n-1}\Delta_1 - a_{n-2}\Delta_2 + \dots - (-1)^n \Delta_n. \end{aligned}$$

To find Δ_n , we write the equations as

$$\begin{aligned} 0 &= a_1 - \Delta_1 \\ 0 &= 2a_2 - a_1\Delta_1 + \Delta_2 \\ 0 &= 3a_3 - a_2\Delta_1 + a_1\Delta_2 - \Delta_3 \\ 0 &= 4a_4 - a_3\Delta_1 + a_2\Delta_2 - a_1\Delta_3 + \Delta_4 \\ &\dots \dots \dots \\ 0 &= (-1)^n \Delta_n + na_n - a_{n-1}\Delta_1 + a_{n-2}\Delta_2 - \dots - (-1)^{n-1} a_1 \Delta_{n-1} \end{aligned}$$

Elimination of $\triangle_1, \triangle_2, \dots, \triangle_{n-1}$, yields at once—

$$0 = \begin{vmatrix} a_1 & 1 & 0 & 0 & \dots & 0 & 0 \\ 2a_2 & a_1 & 1 & 0 & \dots & 0 & 0 \\ 3a_3 & a_2 & a_1 & 1 & \dots & 0 & 0 \\ 4a_4 & a_3 & a_2 & a_1 & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ (n-1)a_{n-1} & a_{n-2} & a_{n-3} & a_{n-4} & \dots & a_1 & 1 \\ na_n + (-1)^n \triangle_n & a_{n-1} & a_{n-2} & a_{n-3} & \dots & a_2 & a_1 \end{vmatrix}$$

It is easy to see that the numerical value of the minor which multiplies the term $(-1)^n \triangle_n$ is 1, and in all cases we get the result—

$$\triangle_n = \begin{vmatrix} a_1 & 1 & 0 & 0 & \dots & 0 & 0 \\ 2a_2 & a_1 & 1 & 0 & \dots & 0 & 0 \\ 3a_3 & a_2 & a_1 & 1 & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \frac{n-1}{n} a_{n-1} & a_{n-2} & \dots & \dots & \dots & a_1 & 1 \\ na_n & a_{n-1} & \dots & \dots & \dots & a_2 & a_1 \end{vmatrix}$$

2° THEOREM II. To establish the generalised Binomial expansion, viz.—

$$(1 + a_1 x + a_2 x^2 + \dots)^n = 1 + D_1 x + D_2 x^2 + \dots$$

where $D_1 = na_1$

$$D_2 = \frac{1}{2!} \begin{vmatrix} na_1 & -1 \\ 2na_2 & \frac{n-1}{n} a_1 \end{vmatrix},$$

$$D_3 = \frac{1}{3!} \begin{vmatrix} na_1 & -1 & 0 \\ 2na_2 & \frac{n-1}{n} a_1 & -2 \\ 3na_3 & \frac{2n-1}{2n-1} a_2 & \frac{n-2}{n-2} a_1 \end{vmatrix},$$

and in general—

$$D_r = \frac{1}{r!} \begin{vmatrix} na_1 & -1 & 0 & 0 & \dots & 0 & 0 \\ 2na_2 & \frac{n-1}{n} a_1 & -2 & 0 & \dots & 0 & 0 \\ 3na_3 & \frac{2n-1}{2n-1} a_2 & \frac{n-2}{n-2} a_1 & -3 & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \frac{r-1}{r} na_{r-1} & \frac{r-2}{r-1} a_{r-2} & \dots & \dots & \dots & \dots & \dots \\ rna_r & \frac{r-1}{r-1} a_{r-1} & \dots & \dots & \dots & \dots & \dots \end{vmatrix} \dots \dots \dots \text{II}$$

Proof: Logarithmic differentiation gives—

$$\begin{aligned} n(a_1 + 2a_2 x + 3a_3 x^2 + \dots)(1 + D_1 x + D_2 x^2 + D_3 x^3 + \dots) \\ = (D_1 + 2D_2 x + 3D_3 x^2 + \dots)(1 + a_1 x + a_2 x^2 + \dots) \end{aligned}$$

Equating the coefficients, we have—

$$\begin{aligned} na_1 &= D_1 \\ n(a_1 D_1 + 2a_2) &= D_1 a_1 + 2D_2 \\ n(a_1 D_2 + 2a_2 D_1 + 3a_3) &= D_1 a_2 + 2D_2 a_1 + 3D_3 \\ n(a_1 D_3 + 2a_2 D_2 + 3a_3 D_1 + 4a_4) &= D_1 a_3 + 2D_2 a_2 + 3D_3 a_1 + 4D_4 \\ &\dots \dots \dots \text{etc. etc.} \end{aligned}$$

Let us find D_4 by writing the above equations as—

$$\begin{aligned} 0 &= na_1 && - \frac{D_1}{n-1} && a_1 D_1 && - \frac{2D_2}{n-2} && - \frac{3D_3}{n-3} \\ 0 &= 2na_2 && + \frac{2n-1}{n-1} a_2 D_1 && - \frac{2D_2}{n-2} && - \frac{3D_3}{n-3} \\ 0 &= 3na_3 && + \frac{2n-1}{n-1} a_2 D_1 && + \frac{2n-2}{n-2} D_2 && - \frac{3D_3}{n-3} \\ 0 &= 4D_4 + 4na_4 && + \frac{2n-1}{n-1} a_3 D_1 && + \frac{2n-2}{n-2} D_2 && + \frac{2n-3}{n-3} D_3. \end{aligned}$$

Elimination gives—

$$\begin{vmatrix} na_1 & 1 & 0 & 0 \\ 2na_2 & \frac{n-1}{n-1} a_1 & -2 & 0 \\ 3na_3 & \frac{2n-1}{n-1} a_2 & \frac{n-2}{n-2} a_1 & -3 \\ 4na_4 & 4D_4 & \frac{2n-1}{n-1} a_3 & \frac{2n-2}{n-2} a_2 & \frac{n-3}{n-3} a_1 \end{vmatrix}$$

The numerical value of the minor which multiplies $(4na_4 - 4D_4)$ is 3! and we get—

$$D_4 = \begin{vmatrix} 1 & na_1 & -1 & 0 & 0 \\ 2na_2 & \frac{n-1}{n-1} a_1 & -2 & 0 & 0 \\ 3na_3 & \frac{2n-1}{n-1} a_2 & \frac{n-2}{n-2} a_1 & -3 & 0 \\ 4na_4 & \frac{3n-1}{n-1} a_3 & \frac{2n-2}{n-2} a_2 & \frac{n-3}{n-3} a_1 & 0 \end{vmatrix}$$

The method is so obvious now and we may at once put down the general formula—

$$D_r = \begin{vmatrix} na_1 & 1 & 0 & \dots & 0 & 0 \\ 2na_2 & \frac{n-1}{n-1} a_1 & -2 & \dots & 0 & 0 \\ 3na_3 & \frac{2n-1}{n-1} a_2 & \frac{n-2}{n-2} a_1 & \dots & 0 & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ r! na_r & \frac{(r-1)n-1}{r-1} a_{r-1} & \dots & \dots & \frac{n-r+1}{n-r+1} a_1 & 0 \end{vmatrix}$$

Note : It is of course to be noted that in I and II the constants a_1, a_2, \dots cannot be unrestricted. For example, they cannot be such as to make the radius of convergence of $\sum a_r x^r$ zero. We must further confine ourselves to the values of x in the interval of convergence. And so on.

3° Some interesting results can be deduced from I and II as follows—

(i) In I put $a_r = \binom{n}{r}$: we get

$$\log (1+x)^n = \frac{\Delta_1 x}{1} + \frac{\Delta_2 x^2}{2} + \dots$$

$$\text{i.e. } n(x) = \frac{x^2}{2} + \frac{x^3}{3} + \dots + \frac{\Delta_1 x}{1} + \frac{\Delta_2 x^2}{2} + \frac{\Delta_3 x^3}{3} + \dots$$

$\therefore \Delta_r = n$, for all r when $a_r = \binom{n}{r}$. That is we have

$$n = \begin{vmatrix} \binom{n}{1} & 1 & 0 & \dots & 0 & 0 \\ 2\binom{n}{2} & \binom{n}{1} & 1 & \dots & 0 & 0 \\ 3\binom{n}{3} & \binom{n}{2} & \binom{n}{1} & 1 & \dots & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\ r\binom{n}{r} & \binom{n}{r-1} & \binom{n}{r-2} & \dots & \binom{n}{2} & \binom{n}{1} \end{vmatrix}$$

(ii) In I put $a_r = \frac{1}{r!}$: we get—

$$\log e^x = \Delta_1 x - \frac{\Delta_2 x^2}{2} + \frac{\Delta_3 x^3}{3} - \dots$$

$$\therefore x = \Delta_1 x - \frac{\Delta_2 x^2}{2} + \frac{\Delta_3 x^3}{3} - \dots$$

$$\therefore \Delta_1 = 1 \text{ and } \Delta_2 = \Delta_3 = \dots = \Delta_r = 0.$$

That is, we get—

$$0 = \begin{vmatrix} \frac{1}{1!} & 1 & 0 & 0 & 0 & \dots & 0 \\ \frac{2}{2!} & \frac{1}{1!} & 1 & 0 & 0 & \dots & 0 \\ \frac{3}{3!} & \frac{1}{2!} & \frac{1}{1!} & 1 & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \frac{r}{r!} & \frac{1}{(r-1)!} & \frac{1}{(r-2)!} & \dots & \dots & \dots & \frac{1}{1!} \end{vmatrix},$$

(iii) In I put $a_r = 1$: we get—

$$\log \frac{1}{1-x} = \Delta_1 x - \frac{\Delta_2 x^2}{2} + \dots$$

$$\text{i.e. } -\log(1-x) = x + \frac{x^2}{2} + \frac{x^3}{3} + \dots = \Delta_1 x - \frac{\Delta_2 x^2}{2} + \dots$$

$$\therefore \Delta_r = (-1)^{r-1}.$$

That is, we get—

$$(-1)^{r-1} = \begin{vmatrix} 1 & 1 & 0 & 0 & \dots & 0 & 0 \\ 2 & 1 & 1 & 0 & \dots & 0 & 0 \\ 3 & 1 & 1 & 1 & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ r & 1 & 1 & 1 & \dots & 1 & 1 \end{vmatrix}$$

(iv) In II put $a_r = \frac{1}{r!}$: we get—

$$\left(1 + \frac{x}{1!} + \frac{x^2}{2!} + \dots\right)^n = \sum D_r x^r$$

$$\text{i.e. } e^{nx} = \sum \frac{n^r x^r}{r!} = \sum D_r x^r$$

$$\therefore \text{ We get } \frac{n^r}{r!} = D_r$$

That is, we get—

$$\begin{array}{c} 0 \\ n^r \end{array} \left| \begin{array}{ccccccc} n & -1 & 0 & 0 & \dots & 0 & 0 \\ 1! & & & & & & \\ 2n & \frac{n-1}{1!} & -2 & 0 & \dots & 0 & 0 \\ 2! & & & & & & \\ 3n & \frac{2n-1}{2!} & \frac{n-2}{1!} & -3 & \dots & 0 & 0 \\ 3! & & & & & & \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ rn & \frac{\overline{r-1} \cdot n-1}{(r-1)!} & & & & & \frac{n-r+1}{1!} \\ r! & & & & & & \end{array} \right|$$

(v) Again, put in II $a_1=a_2=a_3=\dots a_r=1$, we get—

$$\left(\frac{1}{1-x} \right)^n = \sum D_r x^r$$

$$\text{i.e., } 1 + \sum_{r=1}^{\infty} \frac{n(n+1) \dots (n+r-1)}{r!} x^r = \sum D_r x^r$$

That is, we get—

$$\begin{array}{c} n(n+1)(n+2) \dots (n+r-1) \\ = \end{array} \left| \begin{array}{ccccccc} n & -1 & 0 & 0 & \dots & 0 & 0 \\ 2n & \overline{n-1} & 2 & 0 & \dots & 0 & 0 \\ 3n & \overline{2n-1} & \overline{n-2} & -3 & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ rn & \overline{r-1} \cdot n-1 & & & & & \overline{n-r+1} \\ r! & & & & & & \end{array} \right|$$

4° THEOREM III. Exponential Expansion: It is easy to establish that—

$$\begin{aligned} \exp. (a_1 x + a_2 x^2 + a_3 x^3 \dots) \\ = 1 + K_1 x + K_2 x^2 + K_3 x^3 + \dots \end{aligned}$$

where

$$K_r = \frac{1}{r!} \begin{vmatrix} a_1 & -1 & 0 & 0 & 0 & \dots & 0 & 0 \\ 2a_2 & a_1 & -2 & 0 & 0 & \dots & 0 & 0 \\ 3a_3 & 2a_2 & a_1 & -3 & 0 & \dots & 0 & 0 \\ 4a_4 & 3a_3 & 2a_2 & a_1 & -4 & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ r a_r & \overline{r-1} a_{r-1} & \dots & \dots & \dots & \dots & 2a_2 & a_1 \end{vmatrix}$$

Proof: Taking logarithms and then differentiating we get —

$$a_1 + 2a_2x + 3a_3x^2 + \dots = \frac{K_1 + 2K_2x + 3K_3x^2 + \dots}{1 + K_1x + K_2x^2 + \dots}$$

$$\therefore (a_1 + 2a_2x + 3a_3x^2 + \dots)(1 + K_1x + K_2x^2 + \dots) = K_1 + 2K_2x + 3K_3x^2 + \dots$$

Equating the coefficients of like powers we get —

$$\begin{aligned} 0 &= a_1 - K_1 \\ 0 &= 2a_2 + a_1K_1 - 2K_2 \\ 0 &= 3a_3 + 2a_2K_1 + a_1K_2 - 3K_3 \\ 0 &= 4a_4 + 3a_3K_1 + 2a_2K_2 + a_1K_3 - 4K_4 \\ &\dots \dots \dots \\ 0 &= r a_r + \overline{r-1} a_{r-1} K_1 + \dots - r K_r \end{aligned}$$

Taking $-rK_r$ with $r a_r$ in the last and eliminating, as in previous cases, K_1, K_2, \dots, K_{r-1} , we get—

$$0 = \begin{vmatrix} a_1 & -1 & 0 & 0 & \dots & 0 & 0 \\ 2a_2 & a_1 & -2 & 0 & \dots & 0 & 0 \\ 3a_3 & 2a_2 & a_1 & -3 & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ r a_r - r K_r, \overline{r-1} a_{r-1}, & \dots & \dots & \dots & \dots & 2a_2 & a_1 \end{vmatrix}$$

It is easy to see that the numerical value of the minor of $r a_r$ — $r K_r$ is $1 \cdot 2 \cdot 3 \dots r-1$, and we get—

$$K_r = \frac{1}{r!} \begin{vmatrix} a_1 & -1 & 0 & 0 & \dots & 0 & 0 \\ 2a_2 & a_1 & -2 & 0 & \dots & 0 & 0 \\ 3a_3 & 2a_2 & a_1 & -3 & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ r a_r & \overline{r-1} a_{r-1} & \dots & \dots & \dots & 2a_2 & a_1 \end{vmatrix}$$

5° APPLICATIONS: The following applications yield interesting results—

If we put in the above theorem III, $a_r = \frac{1}{r!}$, we have the left hand side—

$$\exp. \left(x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots \right) \text{ i.e. } \exp. (e^x - 1)$$

∴ we get—

$$\exp.c = c (1 + K_1 x + K_2 x^2 + K_3 x^3 + \dots)$$

where now—

$$K_r = \frac{1}{r!} \begin{vmatrix} 1 & -1 & 0 & 0 & \dots & 0 & 0 \\ 1! & 1! & -2 & 0 & \dots & 0 & 0 \\ 1 & 1 & -2 & 0 & \dots & 0 & 0 \\ 2! & 1! & 1! & -3 & \dots & 0 & 0 \\ 1 & 1 & 1 & -3 & \dots & 0 & 0 \\ 2! & 1! & 1! & 1! & -4 & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ 1 & 1 & \dots & \dots & \dots & 1 & 1 \\ (r-1)! & (r-2)! & \dots & \dots & \dots & 1! & 1! \end{vmatrix}$$

The general relation connecting the K s, viz.—

$$0 = r a_r + \overline{r-1} a_{r-1} K_1 + \overline{r-2} a_{r-2} K_2 + \dots - r K_r$$

reduces to—

$$r K_r = \frac{r}{r!} + \frac{r-1}{(r-1)!} K_1 + \frac{r-2}{(r-2)!} K_2 + \frac{r-3}{(r-3)!} K_3 + \dots \\ \dots + \frac{1}{1!} K_{r-1}.$$

Multiplying by $(r-1)!$ we get—

$$r! K_r = 1 + \overline{r-1} K_1 + (r-1)(r-2) K_2 + \dots (r-1)! K_{r-1}.$$

Writing $H_r = K_r \cdot r!$

we get—

$$H_r = 1 + (r-1) H_1 + \frac{\overline{r-1} \cdot \overline{r-2}}{2!} H_2 + \dots + H_{r-1}$$

i.e., symbolically—

$$H_r = (1 + H)^{r-1}$$

it being understood that after the expansion by the Binomial theorem, H, H^2, H^3, H^4, \dots etc. are to be replaced by $H_1, H_2, H_3, H_4, \dots$

We now get with the above notation—

$$\exp.x = e \left(1 + \frac{H_1 x}{1!} + \frac{H_2 x^2}{2!} + \frac{H_3 x^3}{3!} + \dots \right)$$

$$\text{where } H_r = (1 + H)^{r-1}$$

The left hand side is—

$$\begin{aligned} & 1 + \frac{e^x}{1!} + \frac{e^{2x}}{2!} + \frac{e^{3x}}{3!} + \frac{e^{4x}}{4!} + \dots \\ &= \left(1 + \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + \dots \right) \\ &+ \frac{1}{1!} \left(\frac{1}{1!} + \frac{2}{2!} + \frac{1}{3!} + \dots \right) x \\ &+ \frac{1}{2!} \left(\frac{1^2}{1!} + \frac{2^2}{2!} + \frac{3^2}{3!} + \dots \right) x^2 \\ &+ \frac{1}{3!} \left(\frac{1^3}{1!} + \frac{2^3}{2!} + \frac{3^3}{3!} + \dots \right) x^3 \\ &+ \dots \\ &+ \frac{1}{r!} \left(\frac{1^r}{1!} + \frac{2^r}{2!} + \frac{3^r}{3!} + \dots \right) x^r \\ &+ \dots \end{aligned}$$

Thus we get—

$$H_r = \sum_{n=1}^{\infty} \frac{n^r}{n!} = e \begin{vmatrix} \frac{1}{1!} & -1 & 0 & 0 & \dots & 0 & 0 \\ \frac{1}{1!} & \frac{1}{1!} & -2 & 0 & \dots & 0 & 0 \\ \frac{1}{1!} & \frac{1}{1!} & \frac{1}{1!} & -3 & \dots & 0 & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ \frac{1}{(r-1)!} & \frac{1}{(r-2)!} & \dots & \dots & \dots & \frac{1}{1!} & \frac{1}{1!} \end{vmatrix}$$

If we understand by $0! = 1$ and $0^0 = 1$, we get—

$$H_0 \equiv \sum_0^{\infty} \frac{n^0}{n!} = e$$

$$H_1 \equiv \sum_0^{\infty} \frac{n^1}{n!} = e$$

$$H_2 \equiv \sum_0^{\infty} \frac{n^2}{n!} = 2e$$

$$H_3 \equiv \sum_0^{\infty} \frac{n^3}{n!} = 5e$$

Similarly $H_4 = 15e$, $H_5 = 52e$ and in general $H_r = (1 + H)^{r-1}$.

6° Before concluding the note, a word about the example which suggested it.

Given $(1 + a_1 x + a_2 x^2 + a_3 x^3 + \dots)$

$$(1 + a_1' x + a_2' x^2 + a_3' x^3 + \dots) = 1,$$

then $D_r = (-1)^r D'_r$

$$\text{where } D_r = \begin{vmatrix} a_1 & a_2 & a_3 & \dots & a_r \\ a_2 & a_3 & a_4 & \dots & a_{r+1} \\ a_3 & a_4 & a_5 & \dots & \dots \\ \dots & \dots & \dots & \dots & \dots \\ a_r & a_{r+1} & a_{r+2} & \dots & a_{2r-1} \end{vmatrix},$$

Dr. Ram Behari suggests a method which might be illustrated by taking $r = 3$:—

To prove that—

$$\begin{vmatrix} a_1 & a_2 & a_3 \\ a_2 & a_3 & a_4 \\ a_3 & a_4 & a_5 \end{vmatrix} = - \begin{vmatrix} a_1' & a_2' & a_3' \\ a_2' & a_3' & a_4' \\ a_3' & a_4' & a_5' \end{vmatrix}$$

We have the set of equations—

$$a_1 + a_1' = 0$$

$$a_2 + a_1 a_1' + a_2' = 0$$

$$a_3 + a_2 a_1' + a_1 a_2' + a_3' = 0$$

$$a_4 + a_3 a_1' + a_2 a_2' + a_1 a_3' + a_4' = 0$$

$$a_5 + a_4 a_1' + a_3 a_2' + a_2 a_3' + a_1 a_4' + a_5' = 0$$

etc., etc.

Consider the left hand side determinant—

To the elements of the third column, add elements of the second column multiplied by a_1' and those of the first column multiplied by a_2' . And to the elements of the second column add those of the first column multiplied by a_1' . We get—

$$\begin{vmatrix} a_1 & a_2 & a_3 \\ a_2 & a_3 & a_4 \\ a_3 & a_4 & a_5 \end{vmatrix} = \begin{vmatrix} a_1 & a_2 + a_1 a_1' & a_3 + a_2 a_1' + a_1 a_2' \\ a_2 & a_3 + a_2 a_1' & a_4 + a_3 a_1' + a_2 a_2' \\ a_3 & a_4 + a_3 a_1' & a_5 + a_4 a_1' + a_3 a_2' \end{vmatrix}$$

$$= \begin{vmatrix} -a_1' & -a_2' & -a_3' \\ -(a_2' + a_1' a_1) & -(a_3' + a_2' a_1) & -(a_4' + a_3' a_1) \\ -(a_3' + a_2' a_1 + a_1' a_2) & -(a_4' + a_3' a_1 + a_2' a_2) & -(a_5' + a_4' a_1 + a_3' a_2) \end{vmatrix}$$

$$= (-1)^3 \begin{vmatrix} a_1' & a_2' & a_3' \\ a_2' & a_3' & a_4' \\ a_3' & a_4' & a_5' \end{vmatrix}$$

The method is easily extended to any D_r .

Further by using the generalised form of the Binomial theorem we can express a_1' , a_2' , a_3' , .. etc. in terms of a_1, a_2, a_3 ...etc. and vice versa.

Thus—

$$(1 + a_1'x + a_2'x^2 + \dots) = (1 + a_1x + a_2x^2 + \dots)^{-1} = 1 + D_1x + D_2x^2 + \dots$$

Putting $n = -1$ in the formula for D_r obtained in 2°, we get—

$$D_r = (-1)^r \begin{vmatrix} a_1 & 1 & 0 & 0 & \dots & 0 \\ a_2 & a_1 & 1 & 0 & \dots & 0 \\ a_3 & a_2 & a_1 & 1 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots & \dots \\ a_r & a_{r-1} & a_{r-2} & a_{r-3} & \dots & a_1 \end{vmatrix}$$

Thus we get—

$$a_1' = -a_1, \quad a_2' = \begin{vmatrix} a_1 & 1 \\ a_2 & a_1 \end{vmatrix}$$

$$a_3' = - \begin{vmatrix} a_1 & 1 & 0 \\ a_2 & a_1 & 1 \\ a_3 & a_2 & a_1 \end{vmatrix}, \quad a_4' = \begin{vmatrix} a_1 & 1 & 0 & 0 \\ a_2 & a_1 & 1 & 0 \\ a_3 & a_2 & a_1 & 1 \\ a_4 & a_3 & a_2 & a_1 \end{vmatrix}$$

etc., etc.

with similar expressions for a_1, a_2, a_3 ...in terms of a_1', a_2', a_3' ...etc.

SOME INTERESTING APPLICATIONS OF DIAGONALISATION METHOD

By D. R. KAPREKAR, B.Sc., S.T.C.

IN the November 1946 issue of the B. U. J., the symbols D and D were explained and cases of numbers in arithmetical progression were considered. In the present article cases of numbers in Geometrical progression, having common ratio > 1 , and of sequences of numbers formed in accordance with certain fixed laws will be considered.

(2) The following notation and new terms will be used. The word 'diagonalisation' will be shortened to 'dialing'. This dialing will be either to left or right, and not necessarily only 1 place and the symbols $D_k \rightarrow$ and $D_k \leftarrow$ will be used to show shifting of the unit digit of successive numbers through K places to the right and to the left respectively.

Thus taking the sequence of numbers $S = 147, 152, 157, 162, 167, 172 \dots$

$D_2 \rightarrow$ of S

$$\begin{array}{r}
 = 147 \\
 152 \\
 157 \\
 162 \\
 167 \\
 172 \\
 \hline
 = 1485358636872
 \end{array}$$

$D_3 \leftarrow$ of S

$$\begin{array}{r}
 147 \\
 152 \\
 157 \\
 162 \\
 167 \\
 172 \\
 \hline
 = 172167162157152147
 \end{array}$$

(3) The dialing of numbers is arithmetical progression, and methods for obtaining the periods of $\frac{1}{(99)^2}$ and $\frac{1}{(999)^2}$ were considered in the last article.

Now we consider the dialing of numbers in Geometrical progression.

Take the series, 14, 28, 56, 112, 224.... having ratio = 2

Then $D_2 \longrightarrow$ =

$$\begin{array}{r}
 14 \\
 28 \\
 56 \\
 112 \\
 224 \\
 448 \\
 896 \\
 \hline
 = 142857 \quad 142857...
 \end{array}$$

This gives 142857 which is the period for $\frac{1}{7}$ The reason may be pointed out as follows—

$$\begin{aligned}
 \frac{1}{7} &= \frac{14}{100-2} = \frac{14}{100} (1-.02)^{-1} \\
 &= \frac{14}{100} (1+.02+.0004+...) \\
 &= \frac{1}{100} (14+.28+.0056+...) \\
 &= D_2 \longrightarrow (14, 28, ...)
 \end{aligned}$$

In the B. U. J., November 1938, a method giving the period of $\frac{1}{7}$ by left dialing is considered ; it is equivalent to $D_1 \longleftarrow$ of the G. P.: 7, 35, 175, 875 etc. having 5 as common ratio.

Here $D_1 \longleftarrow (7, 35, ...)$

$$\begin{array}{r}
 07 \\
 35 \\
 175 \\
 875 \\
 4375 \\
 21875 \\
 75 \\
 \hline
 = 7142857
 \end{array}$$

and give 142857 the period of $\frac{1}{7}$.

Another method giving the period of $\frac{1}{7}$ can be derived by regarding

$$\frac{1}{7} = \frac{1}{10-3} = \frac{1}{10} (1-.3)^{-1} = \frac{1}{10} (1+.3+.09+.027)$$

this is nothing but $D_1 \longrightarrow$ of numbers 1, 3, 9, 27, 81.....G. P. ratio 3.

Thus we have pointed out 3 dialing methods to give the period of $\frac{1}{7}$.

(4) The recurring periods for fractions like, $\frac{1}{19}$, $\frac{1}{31}$, $\frac{1}{39}$, $\frac{1}{81}$, $\frac{1}{891}$, etc. can also be derived in the same way by the dialing of certain Geometrical progressions.

Thus the recurring period of $\frac{1}{19}$ is given by $D_2 \rightarrow$ of the G.P.
5, 25, 125, 625, 3125.....

Thus

$$\begin{array}{r}
 5 \\
 25 \\
 125 \\
 625 \\
 3125 \\
 15625 \\
 78125 \\
 390625 \\
 \dots\dots \\
 \hline
 5263157894531
 \end{array}$$

The actual Value of $\frac{1}{19}$ is = .052631578947368421

For some other discussion on the same period and also for period of $\frac{1}{7}$, please refer to my article "Some properties of Demlo numbers and their applications to recurring decimals", *Mathematics Student*, June 1939, pages 47 to 51.

(5) Now we turn to the dialing of numbers in a sequence formed according to some other law, that is of numbers which are neither in A.P. nor in G.P.

$D_1 \rightarrow$ of sequence 1, 3, 6, 10, 15, 21, 28..... whose law of formation is $\frac{n(n+1)}{2}$ gives the recurring period of $\frac{1}{729}$. This is the sequence of triangular numbers and it is interesting to note that they give rise to period of $\frac{7}{291}$. Thus

$$\begin{array}{r}
 1 \\
 3 \\
 6 \\
 10 \\
 15 \\
 21 \\
 28 \\
 36 \\
 45 \\
 55 \\
 66 \\
 78 \\
 \hline
 137174211248
 \end{array}$$

The actual period of $\frac{1}{729}$ contains 81 figures, some of which are given below--

$$\frac{1}{729} = .00137174211248 \dots\dots\dots 260631$$

(6) The $D_1 \longrightarrow$ of figurate numbers of the third order gives the period for $\frac{1}{9^3} = \frac{1}{6561}$. The figurate numbers of the third order are formed by the law $\frac{n(n+1)(n+2)}{6}$. These are 1, 4, 10, 20, 35.....

(7) The $D_1 \longrightarrow$ of the numbers of the fourth dimension formed according to law $\frac{n(n+1)(n+2)(n+3)}{24}$ gives the recurring period for $\frac{1}{9^4} = \frac{1}{6561}$.

These numbers are 1, 5, 15, 35, 70.....

(8) The $D_1 \longleftarrow$ of the sequence of numbers known as Fibanocci number gives the period for $\frac{1}{109}$ the law for their formation is $U_n = U_{n-1} + U_{n-2}$ where $u_1 = 1$ and the numbers are 1, 1, 2, 3, 5, 8, 13, 21, 34.....etc. This subject has been already fully discussed by Messrs. A. A. Krishnaswamy Iyanger and D. R. Kaprekar in B. U. J. of November 1945.

(9) If a sequence a_n is defined as $a_n = a_{n-1} + 3(n-1)$ the right dialing or $D_1 \longrightarrow$ of the numbers beginning with 1, viz. 01, 04, 10, 19, 31, 46, 64, 85.....gives the recurring period of $\frac{37}{243}$, which is .015226337448559670,781,8930041.

See question No. 1793 in *Mathematics Student*, Volume VIII, page 141 (Sept. 1940 issue).

Note by the Editor on Mr. Kaprekar's paper (On some interesting applications of the diagonalisation method).

(1) $D_1 \leftarrow$ operating on the sequence a_1, a_2, \dots gives the sum

$$a_1 + 10a_2 + 10^2a_3 + \dots + 10^{n-1}a_n + \dots = \sum_1 10^{n-1}a_n$$

It is therefore equivalent to the operator (1_∞) defined by Ayyangar and Kaprekar on p. 6 of B. U. J., Nov. 1945.

$$\text{Thus } D_1 \leftarrow \{a_n\} = (1_\infty) \{a_n\} = \sum_1 10^{n-1}a_n.$$

In the same way since $D_2 \leftarrow \{a_n\} = a_1 + 100a_2 + 10000a_3 + \dots = \sum_1 a_n \times 10^{2(n-1)}$, we may write

$$D_2 \leftarrow \equiv (\dots 1010101) \{a_n\} = (01)_\infty \{a_n\}$$

$$\text{Similarly } D_k \leftarrow \equiv (0_{k-1}, 1)_\infty \equiv (\dots 01, 00 \dots 01, 00 \dots 01),$$

the result of the operation being obtained by taking the sum of $a_1 \times 1$; $a_2 \times 1, 0_{k-1}$; $a_3 \times 1, 0_{2k-1}$ etc., i.e., by multiplying a_r by the ' r 'th non-zero digit starting from the unit digit, in $(0_{k-1}, 1)_\infty$, with its correct place-value.

$$(2) \text{ Again } D_1 \rightarrow (a_1, a_2 \dots a_n \dots) \text{ or } D_1 \rightarrow \{a_n\}$$

gives $a_1 + 0.1a_2 + 0.01a_3 + 0.001a_4 + \dots$

$$= \sum_1 10^{-(n-1)}a_n$$

$$\therefore D_1 \rightarrow \text{ may be denoted by } (1.11 \dots) = (1.\dot{1})$$

$$(1.\dot{1}) \{a_r\} \text{ being equal to } \sum_1 10^{-(r+1)}a_r$$

$$\text{Then } D_2 \rightarrow = (1.\dot{0}1) \text{ and } D_k \rightarrow = (1.\dot{0}0 \dots \dot{1}) = (1.\dot{0}_{k-1}, \dot{1}).$$

Here we start from the unit's digit and take the successive non-zero ' r 'th digits to the right as multipliers of a_r .

(2) The various results in this paper establish certain correspondences, between recurring decimals and geometrical progressions.

Thus $D_1 \leftarrow$ of the G. P. 7, 35, 175,

$$= \text{ the G. P. } 7(1+50+50^2+\dots)$$

And the sum of n terms $S_n = (50^n - 1)/7$

Also since $\frac{1}{7} = 0.\dot{1}42857$,

$$142857 = 10^6 \times 0.\dot{1}42857 - 0.\dot{1}42857 = (10^6 - 1)/7 = (9)_6/7.$$

Similarly $(142857)_k = (10^{6k} - 1)/7 = (9)_{6k}/7$.

$$\begin{aligned} \therefore \text{ Taking } n=6k, S_{6k} &= (50^{6k} - 1)/7 = (5^{6k} \times 10^{6k} - 1)/7 \\ &= \frac{(5^{6k} - 1) \times 10^{6k} + (10^{6k} - 1)}{7} \end{aligned}$$

This must obviously be an integer; and

$\therefore (10^{6k} - 1)/7 = (142857)_k$,
since $(5^{6k} - 1)/7$ must also be an integer (with the last two digits 32, since $5^{6k} = \dots 625$).

$$\begin{aligned} \therefore S_{6k} &= \dots 32(0)_{6k} + (142857)_k \\ &= \dots 32, (142857)_k. \end{aligned}$$

This proves the result, when the summation is carried out to $6k$ terms, and the last $6k$ digits of the sum are taken.

Again whatever n may be, carrying the summation beyond n terms cannot obviously change the last n digits of the same.

\therefore Since the result holds for $n=6k$ (however large k may be), it must be true for any $n \leq 6k$ i.e., for all values of n whether multiples of 6 or not.

(3) As regards para (4), the given summation is equivalent to the G. P. $5\{1 + \sum_1 (.05)^r\} = 5/0.95$
 $= 100/19$

This must \therefore give the period of $\frac{1}{19}$.

(4) Similarly in para (5),

$$\begin{aligned} \frac{1}{729} &= \frac{1}{9^3} = 10^{-3} (1-0.1)^{-3} \\ &= 10^{-3} \times \left\{ 1 + \frac{3}{10} + \frac{3.4}{2!} \frac{1}{10^2} + \frac{3.4.5}{3!} \frac{1}{10^3} + \dots \right\} \\ &= 10^{-3} \times \left\{ \frac{1.2}{2} + \frac{2.3}{2} \cdot \frac{1}{10} + \frac{3.4}{2} \frac{1}{10^2} + \frac{4.5}{2} \cdot \frac{1}{10^3} + \dots \right\} \\ &= 10^{-3} \times \sum \frac{n(n+1)}{2} \cdot \frac{1}{10^{n-1}}, \text{ which is equivalent to the} \\ &\text{given dialing.} \end{aligned}$$

Paras (6) and (7) can also be dealt with similarly.

(5) The left dialing of Fibanocci's numbers in para (8) has already been discussed by Iyengar and Kaprekar in B. U. J., Nov. 1945.

(6) Lastly for $D_1 \rightarrow$ of a_n , where $a_n = a_{n-1} + 3(n-1)$, $a_1 = 1$.

It may be seen that $a_n = 1 + 3 \frac{n(n-1)}{2}$.

\therefore Right dialing gives $\sum_1^{\infty} 10^{-(n-1)} \left\{ 1 + \frac{3n(n-1)}{2} \right\}$

$$= \sum_1^{\infty} 10^{-(n-1)} + \frac{3}{2} \sum_1^{\infty} (n^2 - n) 10^{-(n-1)}$$

Now $\sum_1^{\infty} 10^{-(n-1)} = 1.1 = \frac{10}{9}$; and $\sum_1^{\infty} \frac{n}{10^{-(n-1)}} = \left(1 - \frac{1}{10} \right)^{-2} = \frac{100}{81}$;

And if $S = \sum_1^{\infty} n^2 \cdot 10^{-(n-1)} = 1 + \frac{2^2}{10} + \frac{3^2}{10^2} + \dots$,

$$\frac{1}{10} S = \frac{1}{10^2} + \frac{2^2}{10^3} + \frac{3^2}{10^4} + \dots$$

$$\therefore \frac{9}{10} S = \sum_1^{\infty} \frac{n^2}{10^{n-1}} = \sum_1^{\infty} \frac{n^2}{10^n} = \sum_1^{\infty} \frac{n^2}{10^{n-1}} - \sum_1^{\infty} \frac{(n-1)^2}{10^{n-1}}$$

$$= \sum_1^{\infty} \frac{2n-1}{10^{n-1}} = 2 \sum_1^{\infty} \frac{n}{10^{n-1}} - \sum_1^{\infty} \frac{1}{10^{n-1}}$$

$$= 2(1-0.1)^{-2} - (1.1)$$

$$= \frac{200}{81} - \frac{10}{9} = \frac{100}{81}$$

$$\therefore S = \sum_1^{\infty} \frac{n^2}{10^{n-1}} = \frac{10}{9} \times \frac{110}{81} = \frac{1100}{729}$$

$$\therefore D_1 \rightarrow \{a_n\} = \sum_1^{\infty} 10^{-(n-1)} + \frac{3}{2} \sum_1^{\infty} \frac{n^2}{10^{n-1}} - \frac{3}{2} \sum_1^{\infty} \frac{n}{10^{n-1}}$$

$$= \frac{10}{9} + \frac{3}{2} \cdot \frac{1100}{729} - \frac{3}{2} \cdot \frac{100}{81} = \frac{370}{243}$$

The period for $\frac{370}{243}$ is therefore obtained.

P.S.—It would be more convenient to use the Symbols LD_k for $D_k \leftarrow$, and RD_k for $D_k \rightarrow$ in future.

SOME PROPERTIES OF THE RECIPROCAL OF $(9)_n^2$ AND THEIR MULTIPLES

BY D. R. KAPREKAR, B.Sc., S.T.C.

(1) **I**T is proposed to discuss in this paper the reciprocals of $(9)_2^2$ and some properties of $(9)_n^2$ and give some applications of these results to the properties of Demlo numbers.

(2) As usual $(9)_n^2$ means the square of $(9)_n$ i.e. of 9 written n times. It was shown in B. U. J. November 1946 that the reciprocal of $(9)_1^2 = \frac{1}{81} = 0.012345679$ which is made up of the digits 0, 1, 2, ..., in A. P. upto 9, omitting the digit 8, the common difference of A. P. being 1. Similarly $\frac{1}{(9)_2^2} = \frac{1}{9801}$ is seen to be $0.00010203, \dots, 10, 11, 12, 13, \dots, 96, 97, 99$.

In this, all consecutive numbers from 0 to 99 occur except the number 98. The numbers are written in the scale of 100 and single digits like 0, 1, 2, ... are written as 00, 01, 02, etc. The period contains 198 digits. The reciprocals of $(9)_n^2$ can similarly be written down, and the number of digits in its period will be found to be $(9)_n \times n$. The first steps will be $(0)_n$; $(0)_{n-1} \times$; $(0)_{n-1} 2$; $(0)_{n-1} 9$; $(0)_{n-2} 10, \dots$ etc. and the last two steps in the period will be $(9)_{n-1} 7$, $(9)_n$, the step $(9)_{n-1} 8$ being absent.

(3) Since in $\frac{1}{9801} = 0.000102, \dots, 96, 97, 99$, all the numbers of the different steps form an A. P. with common difference 1, it follows that in $\frac{K}{9801}$ all the numbers will be in A. P. with a common difference K except at a few places which correspond to the omissions. Thus $\frac{3}{9801} = 000306, \dots, 84, 87, 90, 93, 97$ ^o
(The right hand portion can be seen to be true by multiplying some end digits of $\frac{1}{9801}$ by 3).

As 3 is a divisor of 9801 $\frac{3}{9801}$ reduces to $\frac{1}{3267}$ and the number of digits is not 198 but 66.

Similarly $\frac{9}{9801} = \frac{1}{1089}$ and it will contain an A. P. with common difference 9, and the period will contain 22 digits. It is equal to $.000918, 27, 36, 45, 54, 63, 72, 81, 91$. Here all the numbers are in A. P. except the last which corresponds to the omission involved. It will be seen

that when $K=3, 6, 9, 11$, or some factor of 9801, the period reduces to a simple period where all the numbers in the steps are in A. P., with K as common difference, except at places of omissions.

(4) When K is not a divisor of 9801 the terms of the A. P. may overlap in some places and will have some special peculiarities, *e.g.* consider the case when $K=2$

multiplying the value of $\frac{1}{9801}$ by 2, we get 00, 02, 04, 94, 96, 99, 01, 03, 05, 91, 93, 95, 98.

Here we reach all the even numbers from 00, 02, till 96. The next number is *not* 98 but due to overlapping the quantities come out to be 99, 01, 03, upto 95 and the last number is not 97 but 98. The disappearance of 98 and 97 are due to overlapping. These overlapping places we shall call as leap points ; consideration of these leap points and the actual value of $\frac{K}{(9)^2_2}$ when K is or is not a divisor of $(9)^2_2$ can form the subject matter of some other article.

(5) If K and L are such numbers that $K+L=9801$ then periods of $\frac{K}{9801}$ and $\frac{L}{9801}$ will be complementary to one another with respect to 9999, etc. and if $\frac{K}{9801}$ has an ascending series of terms in A. P then $\frac{L}{9801}$ will have a descending series of terms in A. P. with the same common difference.

e.g. $\frac{1}{9801} = .00, 01, 02, 95, 96, 97, 99$

and $\frac{9800}{9801} = .99, 98, 97, 01, 03, 02, 00$

In each case leap points are places of exceptions. In some particular cases the periods will show special peculiarities in the form ;

Thus $\frac{4461}{9801} = .45, 54, 63, 72, 81, 91, 00, 09, 18, 27, 36$

and $\frac{5337}{9801} = .54, 45, 36, 27, 18, 09, 99, 90, 81, 72, 63.$

The difference of the A. P. is ± 9 or ∓ 9 except at leap points. Each has a period of 22 digits and each pair has exactly the same digits exchanged in the other pair.

(6) We shall now derive a method for finding K , when $\frac{K}{9801}$ = an A. P. with a given common difference d . First we take a particular example to illustrate the process.

Take 15, 20, 25, 30, 35, 40,

This may be put as the sum of

$$\cdot 15 \ 15 \ 15 \ 15 \dots\dots\dots$$

$$\text{and } \cdot 00, 05, 10, 15, 20 \dots\dots\dots$$

i.e. the sum of the fractions $\frac{15}{99} + \frac{5}{9801} = \frac{(15 \times 99) + 5}{9801} = \frac{1490}{9801}$ and hence $K=1490$.

This we can generalise and say that if a is the first term in A. P. and d is the common difference in the expression of $\frac{K}{9801}$ then $K=(a \times 99) + d$ will give the given recurring fraction

$$\text{Thus } 54, 61, 68, \dots\dots\dots \text{when } d=7 = \frac{(54 \times 99) + 7}{9801} = \frac{5353}{9801}$$

$$\text{and } 87, 83, 79, 75 \dots\dots\dots \text{where } d=-4 = \frac{(87 \times 99) - 4}{9801} = \frac{8609}{9801}$$

(7) The first important application of the result above is seen in the application to the product of step numbers. (B. U. J., November 45, pages 10-14).

Thus the product

45, 48, 51.....66 $\times 9801$ can be discussed from this standpoint.

For 45, 48, 51.....66 may be continued and the required result is the difference of two series

$$45, 48, 51 \dots\dots\dots 66 \dots\dots$$

$$\text{and } 69, 72, 75 \dots\dots\dots$$

$$\text{i.e. } \left[\frac{(45 \times 99) + 3}{9801} \times 100^3 - \frac{(69 \times 99) + 3}{9801} \right] \times 9801$$

gives us the value of the product and is equal to $4458 \times 100^3 - 6834 = 4457(9)_{12} 3166$ a result already given in the article already referred to.

(8) The product of step numbers of three digits in A. P. can be found out by the period of $K/998001$ and the result may be generalised. Thus if an A. P. has first term a and these are l terms or digits in each step the common difference being d , the A.P. can be regarded as the recurring period of

$$\frac{a \times (9)_l + d}{(9)_{l-1} 8 (0)_{l-1} 1} \text{ or } \frac{a \times (9)_l + d}{(9)_l}$$

$$\text{e. g. } 4785, 4792, 4799 \dots\dots\dots 4806$$

$$= \frac{4785 \times 9999 + 7}{99980001} = \frac{47845222}{99980001}$$

$$\text{and } 735, 732, 729 \dots\dots\dots$$

$$= \frac{(735 \times 999) - 3}{998001} = \frac{734262}{998001}$$

(9) One more application of the period of $\frac{K}{9801}$ can be seen in the product of Demlo numbers to the base of 100. Thus $(17)_7 \times (21)_7 = 03, 64, 24, 85, 46, 06, 67, 20, 59, 99, 38, 78, 17, 57$.

It will be seen on close observation that the first part is merely the recurring period of $\frac{357}{9801}$ and the second part that of $\frac{2019}{9801}$ out of these the first is an A. P. with common difference = 60 in which figures are

overlapping. It is really the right diagonalisation \xrightarrow{D} of the numbers \xrightarrow{D} 03, 63, 123, 183 and the other is the D of the numbers 20, 59, 98, 137, 176 on A. P. with 39 as common difference.

The product of ordinary demlo numbers in scale 10 or linear demlo numbers can also be easily put down with the period of $\frac{K}{81}$ using the same principle.

Some more interesting results will be given in the next article. (I thank the University of Bombay for the research grant given to me).

**KHARE'S WADA,
DEOLALI.**

Editorial notes on Mr. Kaprekar's paper (Some properties of the reciprocals of $(9)_2^n$ etc.).

Proofs of some of the results given by Mr. Kaprekar are supplied below, with his consent.

(1) To prove that $\frac{1}{(9)_2^n} = 0.00, 01, \dots, 97, 99$.

$$\begin{aligned}
 \frac{1}{(9)_2^n} &= \frac{1}{99^n} = \frac{1}{100^n} \cdot \frac{1}{\left(1 - \frac{1}{100}\right)^n} \\
 &= \frac{1}{100^n} + \frac{2}{100^n} + \frac{3}{100^n} + \dots + \frac{n}{100^{n+1}} + \dots \\
 &= \frac{1}{100^n} + \frac{2}{100^n} + \dots + \frac{99}{100^{100}} + \frac{99+1}{100^{101}} + \frac{99+2}{100^{102}} + \dots + \frac{99+n}{100^{100+n}} \dots \\
 &= \frac{1}{100^n} + \frac{2}{100^n} + \dots + \frac{99}{100^{100}} + \frac{99}{100^{101}} \left(1 + \frac{1}{100} + \frac{1}{100^2} + \dots\right) \\
 &\quad + \frac{1}{100^{99}} \left(\frac{1}{100^2} + \frac{2}{100^3} + \dots + \frac{n}{100^{n+1}} + \dots\right) \\
 &= \frac{1}{100^n} + \frac{2}{100^n} + \dots + \frac{99}{100^{100}} + \frac{99}{100^{101}} \times \frac{100}{99} + \frac{1}{100^{99}} \times \frac{1}{99^n}
 \end{aligned}$$

$$\therefore \frac{1}{99^2} \left(1 - \frac{1}{100^{99}} \right) = \frac{1}{100^2} + \frac{2}{100^3} + \dots + \frac{97}{100^{98}} + \frac{98}{100^{99}} + \frac{99+1}{100^{100}}$$

$$= \frac{1}{100^2} + \frac{2}{100^3} + \dots + \frac{97}{100^{98}} + \frac{99}{100^{99}}$$

$$= 0.00, 01, 02, 03, \dots, 97, 99.$$

$$\therefore \frac{1}{(9)^2_2} = \frac{1}{99^2} = \frac{00, 01, \dots, 97, 99}{99, 99, \dots, 99, 99} = 0.00, 01, 02, \dots, 97, 99.$$

(2) Similarly, in general,

$$\frac{1}{(9)^2_n} = \frac{1}{(10^n - 1)^2} = \frac{1}{10^{2n}} + \frac{2}{10^{3n}} + \frac{3}{10^{4n}} + \dots + \frac{r}{10^{(r+1)n}} + \dots$$

$$= \frac{1}{10^{2n}} + \frac{2}{10^{3n}} + \dots + \frac{10^n - 1}{10^{10^n \cdot n}} + \frac{10^n - 1 + 1}{10^{10^n + 1)n}} + \frac{10^n - 1 + 2}{10^{10^n + 2)n}} + \dots$$

$$= \frac{1}{10^{2n}} + \frac{2}{10^{3n}} + \dots + \frac{10^n - 1}{10^{10^n \cdot n}}$$

$$+ \frac{10^n - 1}{10^{(10^n + 1)n}} \left(1 + \frac{1}{10^n} + \frac{1}{10^{2n}} + \dots \right)$$

$$+ \frac{1}{10^{(10^n + 1)n}} \left\{ \frac{1}{10^{2n}} + \frac{2}{10^{3n}} + \dots + \frac{r}{10^{(r+1)n}} + \dots \right\}$$

$$= \frac{1}{10^{2n}} + \frac{2}{10^{3n}} + \dots + \frac{10^n - 1}{10^{10^n \cdot n}}$$

$$+ \frac{10^n - 1}{10^{10^n + 1)n}} \times \frac{10^n}{10^n - 1} + \frac{1}{10^{(10^n + 1)n}} \times \frac{1}{(9)^2_n}$$

$$\therefore \frac{1}{(9)^2_n} \times \left(1 - \frac{1}{10^{(10^n + 1)n}} \right) = \frac{1}{10^{2n}} + \frac{2}{10^{3n}} + \dots + \frac{10^n - 1}{10^{10^n \cdot n}}$$

$$+ \frac{1}{10^{10^n \cdot n}}$$

$$\therefore \frac{1}{(9)^2_n} \times \frac{(9)(10^n - 1)^n}{10^{(10^n - 1)n}} =$$

$$\frac{1}{10^{2n}} + \frac{2}{10^{3n}} + \dots + \frac{10^n - 3}{10^{10^n(2-n)}} + \frac{10^n - 2}{10^{(10^n - 1)n}} + \frac{10^n}{10^{10^n \cdot n}}$$

$$= \frac{0}{10^n} + \frac{1}{10^{2n}} + \dots + \frac{10^n - 3}{10^{(10^n - 2)n}} + \frac{10^n - 1}{10^{(10^n - 1)n}}$$

$$= 0.00 \dots 0.00 \dots 1.00 \dots 2, \dots, 99 \dots 97, 99 \dots 99$$

where each group is composed of n digits, the total number of digit being $(10^n - 1) \ n = n \times 9_n$

$$\therefore \frac{1}{(9)_2^n} = \frac{00 \dots 00, 00 \dots 01, \dots, 99 \dots 99}{99 \dots 99, 99 \dots 99, \dots, 99 \dots 99}$$

$$\text{i.e. } \frac{1}{(9)_2^n} = 0.00 \dots 0, 00 \dots 1, \dots, 99 \dots 9997, 99 \dots 9999,$$

a recurring decimal with $n \times 9_n$ digits in the period.

(3) Let K be a divisor of 99, and $p = 99/K$.

Then

$$\begin{aligned} \frac{K}{(9)_2^n} &= \frac{K}{99^2} = \frac{K}{100^2} \left(1 + \frac{2}{100} + \frac{3}{100^2} + \dots \right) \\ &= \frac{K}{100^2} \left(1 + \frac{2}{100} + \dots + \frac{p}{100^{p-1}} \right) \\ &\quad + \frac{K}{100^{p+2}} \left(p + 1 + \frac{p+2}{100} + \dots \right) \\ &= \frac{K}{100^2} + \frac{2K}{100^3} + \dots + \frac{Kp}{100^{p+1}} + \frac{Kp}{100^{p+2}} \left(1 + \frac{1}{100} + \frac{1}{100^2} + \dots \right) \\ &\quad + \frac{K}{100^{p+2}} \left(1 + \frac{2}{100} + \frac{3}{100^2} + \dots \right) \end{aligned}$$

\therefore Since $Kp = 99$,

$$\begin{aligned} \frac{K}{99^2} &= \frac{K}{100^2} + \frac{2K}{100^3} + \dots + \frac{99}{100^{p+1}} + \frac{99}{100^{p+2}} \times \frac{100}{99} \\ &\quad + \frac{1}{100^p} \cdot \frac{K}{99^2} \end{aligned}$$

$$\therefore \frac{K}{99^2} \left(1 - \frac{1}{100^p} \right) = \frac{K}{100^2} + \frac{2K}{100^3} + \dots + \frac{99-K}{100^p} + \frac{100}{100^{p+1}}$$

$$\therefore \frac{K}{99^2} \left(1 - \frac{1}{100} \right) = 0.00, (K), (2K), \dots, (99-2K), (100-K)$$

where (K) , $(2K)$ etc., are to be written as numbers of 2 digits, the total number of digits being 2 p.

$$\therefore \frac{K}{99^2} = \frac{00, (K), (2K), \dots, (99-2K), (100-K)}{99, 99, 99, \dots, 99, 99}$$

$$\text{i.e. } \frac{K}{(9)_2^2} = 0.00, (K), (2K), \dots, (99-2K), (100-K);$$

(recurring), when K is a divisor of 99.

The recurring period thus contains the numbers in A.P. ; $0, K, 2K, \dots (p-2)K$ with the addition of $(p-1)K+1$ i.e., $10^n - K$ instead of $(p-1)K$ or $99-K$.

(4) In general, if K is a divisor of 9_n ; and $p = \frac{9_n}{K}$ so that $pK = 9_n = 10^n - 1$, it can be shown in the same way that

$$\begin{aligned} \frac{K}{(9)_n} &= K \left(\frac{1}{10^{2n}} + \frac{2}{10^{3n}} + \dots + \frac{p}{10^{n(p+1)}} \right) \\ &\quad + \frac{1}{10^{n(p+1)}} + \frac{1}{10^{np}} \cdot \frac{K}{(9)_n} \\ \therefore \frac{K}{(9)_n} \left\{ 1 - \frac{K}{10^{np}} \right\} &= \frac{K}{10^{2n}} + \frac{2K}{10^{3n}} + \dots + \frac{pK-K}{10^{pn}} + \frac{pK+1}{10^{pn+n}} \\ &\quad - \frac{K}{10^{2n}} + \frac{2K}{10^{3n}} + \dots + \frac{(p-2)K}{10^{(p-1)n}} + \frac{pK+1-K}{10^{pn}} \\ &= 0 \cdot (0), (K), (2K), \dots, (9_n - 2K), (9_n - K + 1); \end{aligned}$$

where $(0), (K), (2K) \dots$ are to be written as numbers of n digits each, the total number of digits being np .

$$\therefore \frac{K}{(9)_n} = \frac{(0), (K), (2K), \dots, (9_n - 2K), (9_n - K + 1)}{9_n, 9_n, 9_n, \dots, 9_n, 9_n},$$

i.e. $\frac{K}{(9)_n} = 0 \cdot (0), (K), (2K) \dots (9_n - 2k), (9_n - K + 1);$ (recurring),

when K is a divisor of 9_n .

The period thus contains $0, K, 2K, \dots, (p-2)K$ which are numbers in A. P., with the addition of $(p-1)K+1$ i.e., $10^n - K$ instead of $(p-1)K$ or $9^n - K$; and as each of these is to be written as a number of n digits the total number of digits in the period is np .

(5) When K is not a divisor of 9_n Mr. Kaprekar's statements are over-simplified. The proper statements with proofs are deferred to another issue of the Journal for want of space.

—K. R. G.

KINETICS OF CONSECUTIVE REACTIONS: HYDROLYSIS OF NITRILES

PART I

By G. G. MUJUMDAR, K. K. DOLE, AND D. D. KARVE

A STUDY of the published literature reveals the fact that very few systematic investigations of consecutive reactions, *i.e.* reactions which take place in stages, have so far been made. Probably the earliest investigation was made by Harcourt and Esson (Phil. Trans., 156, 193, 1866) who studied the reaction between oxalic acid and potassium permanganate. Later on Meyer (Zeit. Electrochem., 13, 186, 1907) studied the hydrolysis of polybasic acids, and Lowry and Traill (Proc. Roy. Soc., A 132, 416, 1931.) the mutarotation of aluminium benzoyl camphor in carbon tetrachloride solution. Whether a reaction is a consecutive one or not can be conveniently decided by examining the values of $1/t \log a/a-x$; if these values are constant, according to Abel (Zeit. physikal. Chem., 56, 558, 1906), the reaction is completed directly in one stage.

A theoretical study of these reactions was attempted by Walker (Zeit. Physikal. Chem., 28, 177, 1899., Proc. Roy. Soc. Edin., 22, 1898) but a general mathematical theory of the successive reactions of the first order was given by Rakowski (Zeit. physikal. Chem., 57, 321, 1906) who deduced formulæ for the reactions of the types, $M_1 \longrightarrow M_2 \longrightarrow M_3$, $M_1 \longrightarrow M_2 \rightleftharpoons M_3$, $M_1 \longrightarrow M_2 \longrightarrow M_3 \longrightarrow M_4$. These formulæ are complicated and their application to the results of experiments is very difficult. Later Lowry and John (J. C. S., 97, 2634, 1910) deduced equations for the changes of concentrations occurring in a reversible chemical reaction which proceeds in two stages. Mellor (Chemical Statics and Dynamics, Chapter V pp. 98, 114) deduced equations for consecutive non-reversible unimolecular reactions and discussed more complex cases. A solution of the equation derived from the theory of consecutive reactions has been recently given by Selikowitz (J. Chem. Phys. 7, 278, 1939).

With a view to throw further light on the kinetics and mechanism of consecutive reactions, particularly the relative magnitudes of the velocity constants of the reactions, the authors studied the hydrolysis of nitriles, as this reaction offers several advantages. It takes place in two stages, neither of these two stages is reversible, the rate of one of the stages is faster than that of the other, the reaction proceeds at a measurable rate at moderately high temperature, there are no side reactions, and the concentrations of the initial, intermediate and final products can be estimated independently of each other.

The reaction is catalysed by mineral acids and can be represented as

Nitrile \longrightarrow Amide \longrightarrow Ammonium Salt \longrightarrow
Glacial acetic acid was selected as the solvent, because all the reacting

substances and the products of the reaction were found to dissolve in it, and its boiling point was high enough for the reaction to be carried out at high temperatures.

EXPERIMENTAL

Purity of the Materials Used

All the reagents used were either manufactured by Merck or Schering-Kahlbaum or B.D.H., or Johnson and Co., or Eastman Kodak. Some substances were prepared in the laboratory. The purity of all substances was determined by well-known analytical methods.

(1) Acetonitrile,	Laboratory product	B.P. 77-78°C (710 mm.)
(2) Benzonitrile,	" "	B.P. 185°C (" ")
(3) Propionitrile,	Schering-Kahlbaum	B.P. 94°-95° (" ")
(4) N-Butyronitrile,	" "	B.P. 113°-114° (" ")
(5) N-Valeronitrile,	" "	B.P. 137°-139° (" ")
(6) Phenylacetonitrile,	B. D. H.	B.P. 125° (30-mm.)
(7) Phenylpropionitrile,	Schering-Kahlbaum	B.P. 115° (25-mm.)
(8) Glacial Acetic Acid,	Johnson & Co.	B.P. 116°-117° (710-mm.)
(9) Sulphuric Acid,	B.D.H. Analar	
(10) Hydrochloric Acid,	" "	
(11) Magnesium Sulphate,	Analytical Quality Schering-Kahlbaum	
(12) Sodium Hydroxide,	L. Merck	

Experimental Procedure

The nitriles were dissolved in glacial acetic acid and the concentration of the solution was so adjusted that 10 c.c. of the solution contained 1.400 mol.

Hydrolysis was carried out in test-tubes fitted with air condensers. 10 c.c. of the nitrile solution were taken in several test tubes, which were placed in a thermostat adjusted to the desired temperature. The thermostat was either a water- or a paraffin-bath of about six gallons capacity, and the temperature could be maintained constant within ± 0.015 for the water and ± 0.1 for the paraffin bath. 5 c.c. of the catalysing acid (also maintained at the temperature of the bath) were added to the test-tubes and thoroughly mixed. At definite intervals of time the test-tubes were removed, cooled and the amount of the reaction was estimated as described below.

ESTIMATION OF THE REACTION PRODUCTS

The contents of the test-tubes were transferred to a litre flask and the solvent and the catalysing acid were exactly neutralised. The ammonium salt formed in the reaction was estimated by treating it with a fresh precipitate of magnesium hydroxide, which does not affect the nitrile or the amide present in the mixture (cf. Reid, J. A. C. S. 21, 285, 1899). The necessary quantity of magnesium hydroxide was formed by adding to the reaction mixture the required quantities of solutions of magnesium sulphate and sodium hydroxide. Excess of alkali was carefully avoided. The ammonia evolved was distilled off (the undecomposed nitrile, being steam-volatile, is also completely removed during this process) and was absorbed in a known volume (excess) of standard sulphuric acid. The excess of sulphuric acid was titrated against N/10 sodium hydroxide.

For the estimation of the amide a sufficient excess of alkali was added to the reaction mixture and after dilution with water, the ammonia evolved from the amide was distilled off and was estimated in the same manner as described above.

In both the estimations sodium alizarin sulphonate (Alizarin Red. S) was used as indicator.

The initial concentration (a) of the nitrile was determined by completely converting it into the amide and the ammonium salt, by refluxing 10 c.c. of the nitrile solution with 20 c.c. of about 22 N sulphuric acid for not less than six hours. The amide and the ammonium salt were estimated as described above.

For calculating the velocity constants, the formula for unimolecular reactions was applied, the two consecutive reactions being pseudo-unimolecular.

In the table of results ' t ' represents the time in minutes, ' a ' the initial concentration of the nitrile, ' x ' the sum of the amounts of ammonium salt and the amide, ' $a-x$ ' the quantity of the undecomposed nitrile at the time ' t ', ' k_1 ' the velocity constant of the reaction nitrile to amide, k_2 (not determined directly) the velocity constant of the reaction amide to ammonium salt, ' K ' the velocity constant of the direct reaction nitrile into ammonium salt and has been calculated by taking ' x ' to be the concentration of the ammonium salt alone.

RESULTS

(1) HYDROLYSIS OF ALIPHATIC NITRILES

Aceto-, propio-, N-butyro- and N-valero-nitrile were hydrolysed by 22.00 N sulphuric acid (the resultant concentration of sulphuric acid in the reaction-mixture being 22/3 N), at different temperatures. The detailed typical results obtained in the case of N-valeronitrile are given in tables 1-4. Similar results were obtained with other aliphatic nitriles.

TABLE 1

N-VALERONITRILE

- (a) *Nitrile* :— Nitrile taken for each observation = 0.2175 gm. = 25 c.c. of N/10 sulphuric acid (Actual ' a ' = 24.45 c.c. for Table Nos. 1, 2 and 3; and 24.95 c.c. for Table No. 4).
- (b) *Solvent* :— Acetic acid solution of nitrile used for each observation = 10 c.c.
- (c) *Catalyser* :— 5 c.c. of 22.00 N. sulphuric acid were used for each observation. After the addition of the catalyser to the nitrile solution the final concentration of the catalyser in the reaction-mixture becomes 22.00/3 N.
- (d) *Temperature* :— 60°C ($\pm 0.025^\circ$)

t	Amm. salt	Amide	Total NH_3	k_1	K
60 min.	0.35	1.80	2.15	0.001533	0.000241
90 "	0.40	2.45	2.85	0.001375	0.000188
120 "	0.45	3.25	3.70	0.001365	0.000155
150 "	0.50	4.00	4.50	0.001354	0.000138
180 "	0.60	4.65	5.25	0.001342	0.000115
210 "	0.60	5.40	6.00	0.001340	0.0000985
			Mean k_1 =	0.001350	

TABLE 2

(a), (b) and (c) same as for Table 1.

(d) Temperature : -70°C ($\pm 0.025^{\circ}$)

t	Amn. salt	Amide	Total NH_3	k_1	K
60 min.	0.60	4.10	4.70	0.003553	0.0004140
90 "	0.70	5.90	6.60	0.003494	0.0003276
120 "	0.80	7.20	8.00	0.003296	0.0002587
150 "	0.95	8.60	9.55	0.003298	0.0002637
180 "	1.00	9.75	10.75	0.003215	0.0002325
210 "	1.20	11.20	12.40	0.003365	0.0002391
			Mean k_1	0.003300	

TABLE 3

(a), (b) and (c) same as for Table 1.

(d) Temperature : -80°C ($\pm 0.025^{\circ}$)

t	Amn. salt	Amide	Total NH_3	k_1	K
60 min.	0.65	9.85	10.50	0.009340	0.0004484
90 "	1.10	12.90	14.00	0.009435	0.0005111
120 "	1.60	14.40	16.00	0.008842	0.0005634
150 "	2.20	15.75	17.85	0.008822	0.0006270
180 "	2.80	16.55	19.35	0.008702	0.0006744
210 "	3.30	17.90	21.20	0.008322	0.0006900
			Mean k_1	0.009000	

TABLE 4

(a), (b) and (c) same as for Table 1.

(d) Temperature : -90°C ($\pm 0.05^{\circ}$)

t	Amn. salt	Amide	Total NH_3	k_1	K
15 min.	0.40	8.10	8.50	0.02775	0.0008355
30 "	0.90	12.75	13.65	0.02623	0.001227
45 "	1.45	15.90	17.35	0.02638	0.001265
60 "	2.10	17.55	19.65	0.02579	0.001464
75 "	2.70	18.65	21.30	0.02560	0.001520
90 "	3.40	19.05	22.45	0.02553	0.001628
120 "	4.95	18.85	23.80	0.02561	0.001842
150 "	6.15	18.15	24.30	0.02429	0.001884
180 "	7.35	17.15	24.50	..	0.001934
210 "	8.50	16.35	24.85	..	0.001982
240 "	9.60	15.30	24.90	..	0.002022
270 "	10.65	14.30	24.95	..	0.002060
300 "	11.55	13.40	24.95	..	0.002070
330 "	12.45	12.50	24.95	..	0.002084
360 "	13.25	11.70	24.95	..	0.002094
390 "	13.75	11.20	24.95	..	0.002045
			Mean k_1	0.02550	

The above tables show that the values of k_1 are fairly constant, showing that the decomposition of nitrile to amide follows the unimolecular law. The values of K in table 1 show a distinct fall, while those in tables 3 and 4 definitely increase. Possibly the earlier stages of the period of induction are accompanied by a fall in the K values, which afterwards become constant till the end of the induction period. The increasing values of K show that acceleration sets in after the period of induction is over. In table 4, K attains a constant value after about 210 minutes, this being the time taken to complete the first sub-reaction.

It will be seen from all the tables that with the progress of time the concentration of the amide increases to a maximum value and then decreases. This indicates that the first sub-reaction is faster than the second one.

The curves for the values of ($K \times 10^5$) against time at different temperatures are shown in Fig. 1 and those for the amounts of undecomposed nitrile (III), the amide (II) and the ammonium salt (I) against time at 90°C in the Fig 2. All these curves clearly show the period of induction and the period of acceleration which finally terminates in the constant values of K . In Fig. 2, the concentration of the amide is seen to pass through a maximum.

(2) HYDROLYSIS OF AROMATIC NITRILES

The velocity of hydrolysis of some typical nitriles belonging to the aromatic series was then studied in the presence of 22.00 N sulphuric acid (the resultant concentration being 22.3 N) at different temperatures. The nitriles used were, benzo-, phenylaceto-, and phenylpropio-nitrile. Detailed results for phenylacetoneitrile (typical representative of aromatic nitriles) are given below. Similar results were also obtained in the case of other nitriles.

TABLE 5
PHENYLACETONITRILE

- (a) *Nitrile* :— Weight of the nitrile taken for each observation = 0.2925 gm. = 25 c.c. of N/1 sulphuric acid (Actual 'a' = 25.50 c.c.)
- (b) *Solvent* :— 10 c.c. of glacial acetic acid solution of nitrile used for each observation.
- (c) *Catalyser* : 5 c.c. of 22.00 N sulphuric acid were used for each observation. After the addition of the catalysing acid to the reaction mixture the resultant concentration of the catalysing acid in the reaction mixture becomes $\frac{22}{3}$ N.
- (d) *Temperature* :—60°C ($\pm 0.025^\circ$).

t	Amm. salt	Amide	Total NH ₃	k_1	K
60 min.	0.15	1.75	1.90	0.001287	0.0000958
90 "	0.20	2.30	2.50	0.001145	0.0000869
120 "	0.25	3.00	3.25	0.001133	0.0000805
150 "	0.35	3.65	4.00	0.001130	0.0000905
180 "	0.40	4.30	4.70	0.001130	0.0000869
210 "	0.50	4.85	5.35	0.001118	0.0000942
Mean k_1 =				0.001135	

TABLE 6

(a), (b) and (c) are the same as for Table 5.

(d) *Temperature* : $70^{\circ}\text{C} (\pm 0.025^{\circ})$.

t	Ammon. salt	Amide	Total NH_3	k_1	K
60 min.	0.35	3.60	3.95	0.002801	0.0002261
90 ..	0.55	5.10	5.65	0.002773	0.0002402
120 ..	0.75	6.40	7.15	0.002736	0.0002472
150 ..	1.00	7.55	8.55	0.002718	0.0002653
180 ..	1.30	8.00	9.30	0.002523	0.0002900
210 ..	1.65	9.55	11.20	0.002751	0.0003174
			Mean k_1	0.002740	

TABLE 7

(a), (b) and (c) same as for Table 5.

(d) *Temperature* : $80^{\circ}\text{C} (\pm 0.025^{\circ})$.

t	Ammon. salt	Amide	Total NH_3	k_1	K
60 min.	0.75	8.40	9.15	0.007399	0.0004945
90 ..	1.75	10.80	12.55	0.007520	0.0007898
120 ..	2.85	12.40	15.25	0.007586	0.0009852
150 ..	4.00	13.20	17.20	0.007474	0.001136
180 ..	5.10	13.70	18.80	0.007415	0.001240
210 ..	6.30	13.80	20.10	0.007384	0.001348
			Mean k_1	0.0075	

TABLE 8

(a), (b) and (c) same as for Table 5.

(d) *Temperature* : $-90^{\circ}\text{C} (\pm 0.05^{\circ})$.

t	Ammon. salt	Amide	Total NH_3	k_1	K
15 min.	0.50	6.45	6.95	0.02128	0.001319
30 ..	1.45	11.00	12.45	0.02331	0.001952
45 ..	2.60	13.30	15.90	0.02268	0.002392
60 ..	3.85	14.65	18.50	0.02152	0.002721
75 ..	5.20	15.25	20.45	0.02157	0.003368
90 ..	6.60	15.10	21.70	0.02113	0.003293
120 ..	9.90	13.80	22.90	..	0.003590
50 ..	11.45	12.50	23.95	..	0.003970
180 ..	13.50	11.00	24.50	..	0.004180
210 ..	15.15	9.85	25.00	..	0.004530
240 ..	16.45	9.05	25.50	..	0.004550
			Mean k_1	0.02140	

TABLE 9

(a), (b) and (c) same as for Table 5.

(d) *Temperature* :—100°C ($\pm 0.05^\circ$).

t	Amm. salt	Amide	Total NH ₃	k ₁	K
60 min.	10.50	13.95	24.45	0.05310	0.008830
90 "	14.95	10.35	25.30	0.05380	0.009790
120 "	17.95	7.55	25.50	..	0.01015
150 "	19.95	5.55	25.50	..	0.01025
180 "	21.50	4.00	25.50	..	0.01025
210 "	22.45	3.05	25.50	..	0.01010
			Mean k ₁ =	0.05380	

The above results show that phenyl acetonitrile hydrolyses more rapidly than propionitrile. This may be due to the position of the cyanide group in the side chain, since benzo- and other nitriles in which the cyanide group is attached to the nucleus hydrolyse comparatively slowly.

The values of K are constant in the beginning ; with the progress of the reaction they increase slightly at first and then rapidly until finally they become constant. Thus they demonstrate, respectively, the periods of induction and acceleration, and of constancy of K when only the simple amide hydrolysis takes place, the first sub-reaction having terminated.

All the tables show that the concentration of the amide at first increases, reaches a maximum value and then decreases. This indicates that the first sub-reaction is faster than the second.

These results clearly show that the aromatic nitriles behave in a manner similar to the aliphatic nitriles towards the hydrolysing agent.

The graphs shown in Figs. 3 and 4 correspond to those in Figs. 1 and 2, and bring out all the features of the consecutive reactions mentioned above.

It will be seen from the above that each of the two non-reversible and consecutive reactions involved in the hydrolysis of nitriles obeys the unimolecular law, if water is in excess. Also the first of these reactions is faster than the second.

The early stages of all the consecutive reactions are abnormally slow, that is, all such reactions exhibit the period of induction. Lowry and John (loc. cit.) have mentioned that the growth of the third product is represented by the curves which exhibit a period of induction whose existence is demonstrated by the constancy of the initial concentrations of the third product. Lowry and Glover (J. C. S., 103, 913, 1913), Lowry

and Smith (J. C. S., 666, 1928) and Hinshelwood and co-workers (J. C. S., 123, 2730, 1923; *ibid*, 125, 1841, 1924) have also observed the period of induction during the course of their investigations.

The period of induction is also clearly seen in the early stages of the hydrolysis of nitriles, when the values of K are constant in all cases. at low temperatures when the earlier stages of the reaction can be studied in detail on account of the low velocity change, the values of K decrease with time. This indicates that the period of induction, which is due to the slow change, is preceded by a period of falling values of K when the change must be still slower (*cf.* Table I and Figs. 1 and 3). The duration of the period of induction is shortened as the temperature of the reaction is increased; at higher temperatures it becomes impossible to observe the period of induction.

In consecutive reactions the period of induction is followed by a period of acceleration. In this period the values of K distinctly rise. Lowry and John (*loc. cit.*) state that "the growth of the concentration of the third product is represented by inflated curves which demonstrate a point of inflection after the period of induction." Similarly Lowry and Glover (*loc. cit.*) observed, in addition to the period of induction, two periods of acceleration from which they concluded that the mutarotation takes place in three consecutive stages. Lowry and Traill (*Proc. Roy. Soc., A*, 132, 416, 1931) and Hinshelwood and co-workers (*loc. cit.*) also found a pronounced acceleration of the reaction which follows the initial period of a very slow change.

The present investigation not only clearly demonstrates but also offers an experimental explanation for the occurrence of the period of acceleration. It has been observed that at higher concentration of the catalysing acid the hydrolysis of nitrile to amide is faster than that of the amide to ammonium salt. This difference in velocities of the two reactions causes the accumulation of the intermediate product (amide) upto a certain maximum concentration. This has been predicted on theoretical grounds by many workers (*cf.* Lowry and co-workers, *loc. cit.*) but has been actually observed in the present investigation, probably for the first time. Thus the occurrence of the maximum concentration of the amide depends upon the relative values of k_1 and k_2 .

The formation of the final product (ammonium salt) depends upon the hydrolysis of the intermediate product (amide) and hence as the reaction progresses the values of K increase first rapidly and then slowly and afterwards become constant. The period of acceleration observed in the mutarotation curves, described by the various authors, also ends in the constant values of the rotation. Walker (*Zeit. physikal. Chem.*, 28, 177, 1899; *Proc. Roy. Soc. Edin.*, 22, 22, 1898) has concluded that an error is introduced by calculating the final product as if the reaction took place directly in one stage instead of two. This error is due to the induction and the acceleration of the reaction which account for the deviation from the unimolecular law.

A glance at the various tables will show that the end of the hydrolysis of nitrile to amide is simultaneous with the end of the period of acceleration. This means that as soon as the original nitrile disappears

from the system, the reaction is no more a consecutive one, but a simple one-stage hydrolysis of the amide into the ammonium salt. The constant values of K are therefore the values of k_2 . These conclusions are in agreement with the observation of Abel (*loc. cit.*).

Recently Krieble and Noll (*J. A. C. S.*, 61, 560, 1939) have obtained some results for the hydrolysis of nitriles, which when compared with those obtained in this investigation seem to be anomalous. They assume that the amide hydrolysis is considerably faster than the nitrile hydrolysis, so that the calculations based on x =ammonium salt hold good for the nitrile hydrolysis. This assumption of these authors is wrong, as according to our results the first stage is much faster than the second at high concentrations of the catalysing acid. Thus the values obtained by Krieble and Noll do not represent the nitrile but probably the amide hydrolysis. For the true study of the nitrile hydrolysis the concentration of the amide must also be taken into account in addition to the concentration of the ammonium salt.

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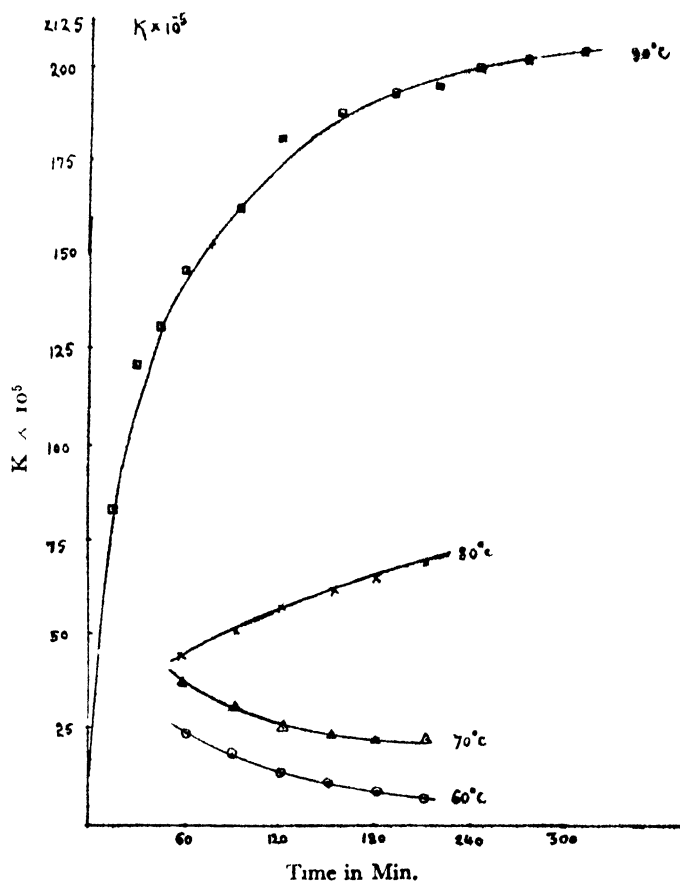
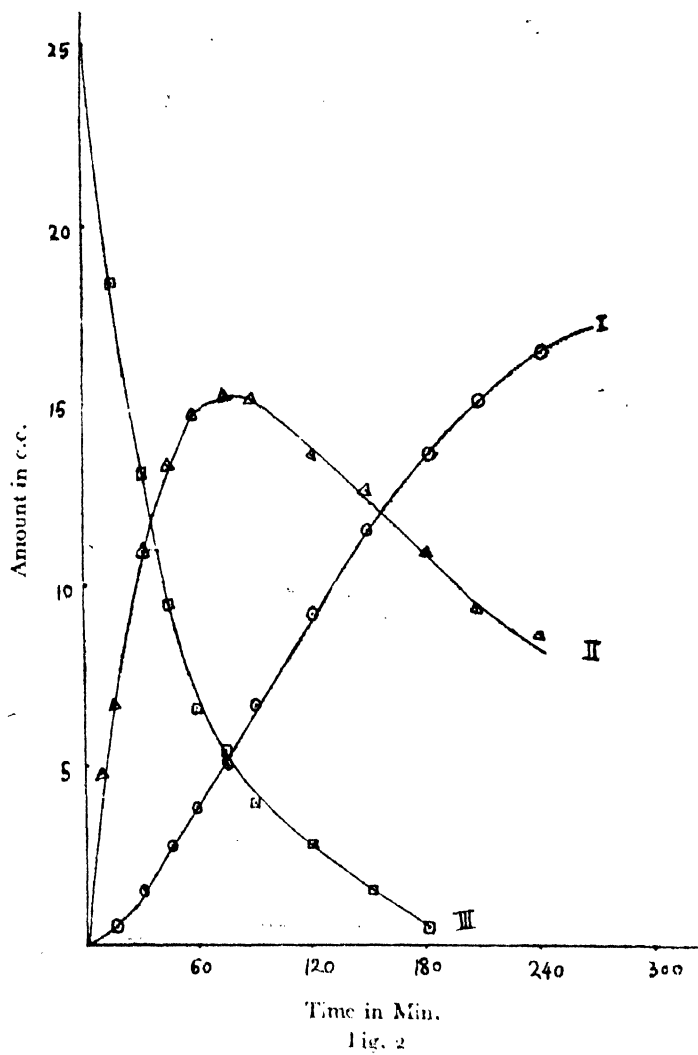


Fig. 1



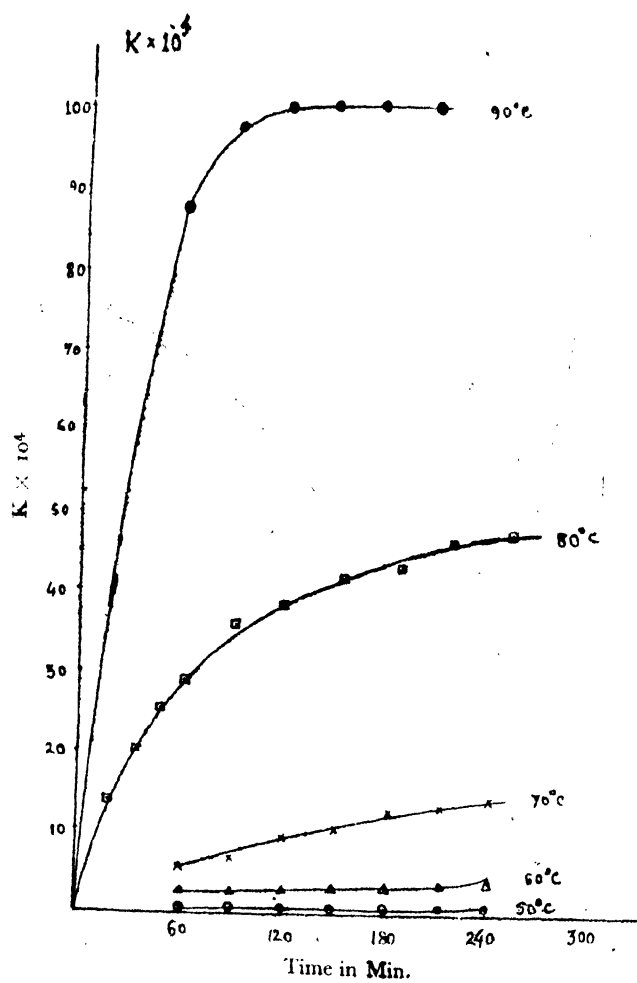


Fig. 3

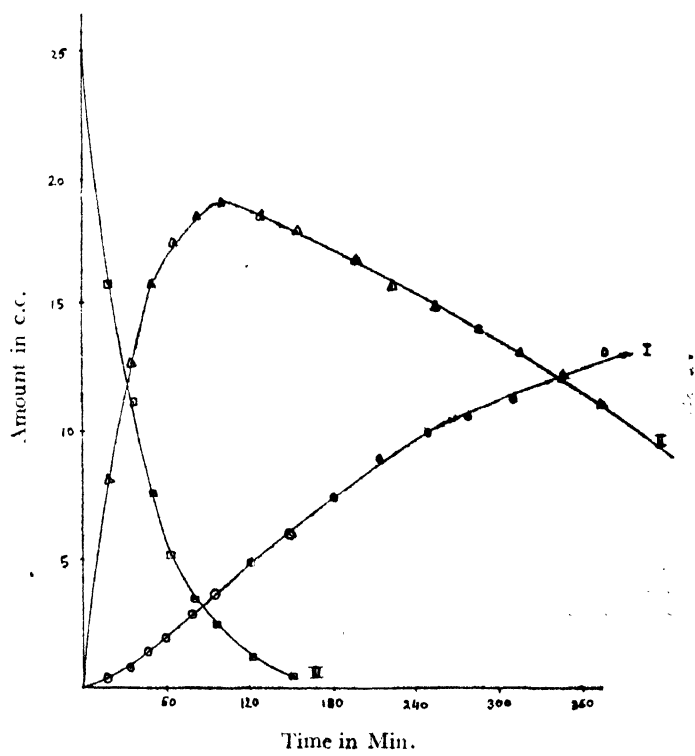
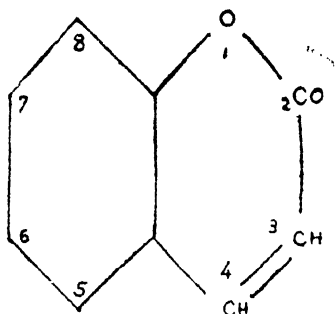


Fig. 4

REACTIVITY IN COUMARIN RING SYSTEM

BY V. M. THAKOR AND N. M. SHAH

IT is well known that coumarin or benzo- α -pyrone does not easily undergo substitution both in the benzenoid as well as in the pyrone part of the molecule. The benzenoid part of the coumarin ring system is not so reactive as a simple benzene derivative. The introduction of certain groups like methyl, hydroxyl, etc., however, weakens this inhibitive effect and renders the molecule susceptible to substitution reactions like nitration, sulphonation, formylation, etc. In simple coumarin, whenever the substitution occurs, the first substitution invariably takes place in position of 6 of the coumarin ring system



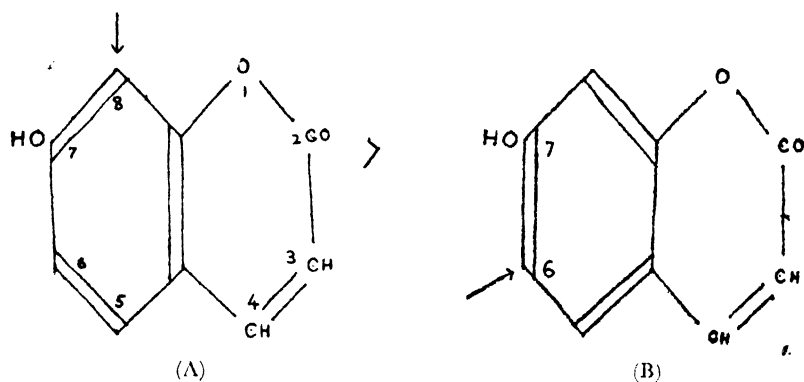
Perkin (J., 1871, 24, 37) sulphonated coumarin and obtained mono-sulphonic acid at the temperature of waterbath and disulphonic acid at higher temperature. Sen and Chakravarti (J.I.C.S., 1928, 5, 433) also obtained a mono-sulphonic acid on sulphonating coumarin, which they proved to be coumarin-6-sulphonic acid. They were also able to get coumarin-3 : 6-disulphonic acid by carrying out the sulphonation at higher temperature. The same authors found that on mercuriation 6-monochloromercuric and 6 : 8-dichloromercuric coumarins were formed (ibid., 1929, 6, 847), while attempts to introduce aldehyde group resulted in the formation of 6-aldehydocoumarin (J. A. C. S., 1928, 50, 2428). The nitration has been exhaustively investigated ; it proceeded with exclusive substitution in position 6 (Delalande, Ann., 1843, 45, 337; Bleibtren, ibid, 1904, 95, 1233 ; Morgan, J., 1904, 85, 1231 ; Francis, Ber., 1906, 39, 3798) but Dey and Krishnamurti (J. I. C. S., 1927, 4, 197) have revealed the simultaneous formation of a small quantity of 8-nitro-coumarin also. On further nitration, 6-nitro-and 8-nitrocoumarins give 3 : 6-and 6 : 8-dinitrocoumarins respectively and finally 3 : 6 : 8-trinitroderivative is formed (Clayton, J., 1910, 97, 1388). The above results indicate that qualitatively so far as monosubstitution is concerned, position 6 appears considerably more reactive than either position 3 or position 8.

On the other hand, in 7-hydroxycoumarin, the first substitution occurs in position 8. Limaye and Joshi (Rasayanam, 1941, 1, 225) carried out the Fries migration of 7-acetoxycoumarin which gave predominantly 8-acetylcoumarin derivative accompanied with a minute quantity of 6-acetyl isomer. Clayton (loc. cit) found that the nitration of 7-hydroxycoumarin results in the formation of 8-nitro derivative. Chakravarti and Ghosh (J. I. C. S., 1935, 12, 791) found that little of 6-nitrocoumarin was also simultaneously formed during the nitration. In the nitration of 7-hydroxy-4-methylcoumarin, Pechmann and Obermiller (Ber., 1901, 34, 666) got a mixture from which they isolated 8-nitro derivative, while Naik and Jadhav (private communication) have isolated 6-nitro derivative from the mixture by carrying out the nitration under the same conditions and concluded that both 6-and 8-nitro derivatives are formed. In the Claissen transformation of 7-allyloxy-4-methylcoumarin, Baker and Lothian (J., 1935, 628) obtained 7-hydroxy-8-allylcoumarin derivative. The formylation also yielded 8-aldehydocoumarin derivative (Späth and Pailer, Ber., 1935, 68, 941; Rangswami and Seshadri, Proc. Indian Acad. Sci., 1937, 6A, 112). The Fries migration of 7-acetoxy-4-methylcoumarin yields 8-acetyl derivative as a major product, a small amount of 6-acetyl isomer also being formed (Limaye, Ber., 1932, 65, 375; Rasayanam, 1936, 1, 15; Thakor and Shah, J. I. C. S., 1946, 23, 199). Thus in 7-hydroxy or 7-hydroxy-4-methylcoumarin, the most reactive position is 8, but 6-position has some significant reactivity: the position 3 comes last.

The esters of 5-hydroxy-4-methylcoumarin undergo Fries rearrangement to give 6-acyl or aroyl coumarin derivative (Sethna, Shah and Shah, J., 1938, 228, 1424; 1939, 1250). The nitration of the above coumarin leads to 6-nitro and 6 : 8-dinitro derivatives (Parekh and Shah, J. I. C. S., 1942, 19, 335).

8-Hydroxycoumarin gives interesting results: while 8-hydroxycoumarin yields 7-nitro and 5 : 7-dinitro derivatives, 8-methoxycoumarin gives 5-nitro derivative (Dey and Kutti, Proc. Nat. Inst. Sci., India, 1940, 6, 641). Thus masking the hydroxyl group by methylation changes the reactivity in this case. 7-methylcoumarin on nitration yields 6-nitro- and 6 : 8-dinitro derivatives: while 4 : 7-dimethylcoumarin produces 6-nitro and 3 : 6-dinitrocoumarin derivatives. Thus the methyl group in 4-position increases the reactivity of 3-position. Again 6 : 7-dimethylcoumarin gives 5-nitro-, 5 : 8 dinitro- and 3 : 5 : 8-trinitrocoumarin derivatives. Thus 6-methyl group renders 5-position reactive (Clayton, loc. cit.). It is obvious that methyl group has also significant directive influence.

Rangswami and Seshadri (Proc. Indian Acad. Sc., 1941, 14A, 547) have attempted to explain the reactivity of the 7-hydroxycoumarin derivatives on the theory of fixation of double bonds (Mills and Nixon, J., 1930, 2510). In coumarin, this fixation of double bonds will take place in such a way that a double bond is common to both the rings. As a result, in 7-hydroxy coumarin, the position 8 will be reactive, being joined by a double bond to carbon atom bearing the hydroxyl group (Structure A). But this does not account for the formation of 6-isomer, which can only be explained by assuming the double bond between C₇ and C₈ atoms (Structure B). Rangswami



and Seshadri after a careful study have come to the conclusion that while the normal structure in coumarin is one with a double bond common to both the rings (Structure A), the other structure (B) is not precluded. Thus the fixation theory does not satisfactorily account for all the recorded observations, if this fixation is taken to be rigid.

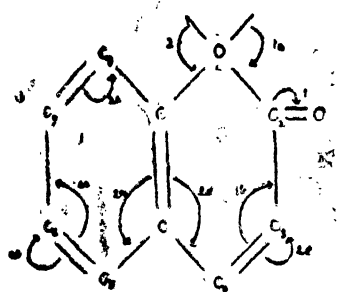
The recently developed theory of resonance (Pauling and Sherman, *J. Chem. Phys.*, 1933, *1*, 605 ; Pauling, Brockway and Beach, *J. A. C. S.*, 1935, *57*, 2705) seems to eliminate this difficulty. According to this theory, the actual structure of coumarin can be neither A nor B, but some intermediate between the two. If A is of materially lower energy than B, the actual structure will resemble more closely to the structure of the lower energy (A). Since the structure with a double bond common to both the rings possesses lower energy (due to less distortion of valence bonds) the actual structure will resemble more to the structure (A) and hence the reactivity will be manifested according to the structure (A) and '6' position will be less reactive than 8-position.

The above review indicates that no comprehensive interpretation has yet been attempted for different reactivity in simple coumarin or in the substituted coumarin ring system when substituents producing powerful electromeric effects are present in the system. This paper is an attempt to explain the reactivity of various positions and also the influence of various substituents in the coumarin ring in terms of electronic theory as advanced by Robinson (Institute of Chemistry, Lectures, April 1932).

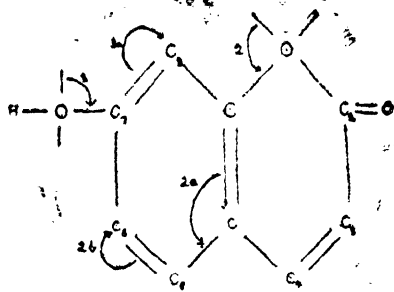
In coumarin or benzo- α -pyrone there are several systems at work simultaneously, viz., (i) anionoid O, (ii) kationoid C=O, and (iii) system of conjugated double bonds, which help electron drifts considerably.

The oxygen of C=O, being kationoid, will cause electron displacements towards itself (see figure 1). Hence C₂ atom will try to make up its electron deficit by attracting electrons from its neighbouring atoms. This it does in part from the anionoid oxygen (1a), as well as for C₃ (1b), which being joined by a double bond to C₄ possesses anionoid character. As a result, the kationoid reactivity of C=O will be nullified, while both oxygen and the double bond between C₃ and C₄ will partly lose their anionoid character,

The oxygen atom in position 1 of the coumarin ring system plays an important role in determining the reactivity of simple coumarin. Being anionoid, it causes the electron drifts as shown by 2 (as well as 2a, 2b, 2c). As a result, both C_3 and C_8 will have increased electron availability and hence they will be reactive (C_6 corresponds to para position in phenol). C_6 will be more reactive than C_3 , being in proximity to O. In similar manner, C_3 will be reactive (2d), but being nearer to $C=O$, C_3 will exhibit less reactivity than C_6 .



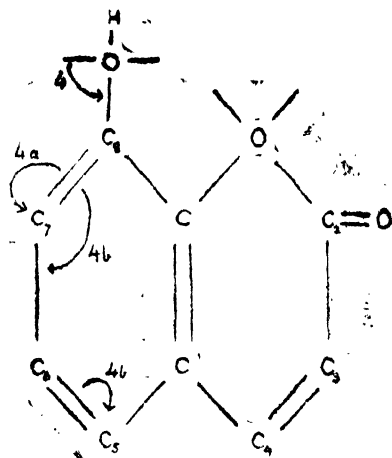
(FIGURE I)



(FIGURE II)

It is obvious that the homogeneous collaboration of both these systems will diminish the number of chances for either system to operate independently. The permanent electronic displacement will be greater, which subsequently will impart a definite dipole character and a tendency to form associated molecular complexes. The kationoid $C=O$ will diminish the anionoid reactivity of oxygen. Also the anionoid reactivity conferred to the molecule by O, through the system of conjugated double bonds will also diminish, particularly of C_3 , while kationoid reactivity of $C=O$ will be almost nullified. Hence in simple coumarin, the most reactive position will be 6, but 8 may react during the formation of a mono derivative as both have increased electron availability. In the formation of disubstituted derivatives the next to react will be the 3 position and 8 will react last. The experimental evidence cited before is in uniformity with the above explanation. An obvious exception to the above is the bromination of coumarin, which is found to occur first in position 3 of the coumarin nucleus and not in 6-position, as should ordinarily be the case (Simonis and Peters, Ber., 1908, 41, 830; Simonis and Wenzel, *ibid.*, 1900, 33, 421, 1962). But Perkin (J., 1870, 23, 368; 1871, 24, 37) has shown that bromination of coumarin is essentially an addition reaction. It produces 3:4-dibromo product, which then loses hydrobromic acid, giving 3-bromocoumarin.

In hydroxycoumarins the oxygen of the hydroxyl exerts a dominating influence. For example, in 8-hydroxycoumarin, the hydroxyl group almost rearranges the reactivity of coumarins. The anionoid 'O' causes electron displacement and renders the 7-position reactive (4, 4a). (Figure III), 5-position also becomes reactive (4b), while reactivity of the ordinarily reactive 6-positions is subdued (cf. Dey and Kutti, *loc. cit.*). In 7-hydroxycoumarin, similar electron drifts (3, 3a) (Figure II) increase the reactivity of 8-position, making it the most reactive. But 6-position will also show significant reactivity on grounds



(FIGURE III)

already discussed for simple coumarin. The 3-position will be the last to react. This finds support in the literature cited above.

In 5-hydroxy-4-methylcoumarin, the electron drifts caused by the oxygen of the hydroxyl increases the reactivity of both '6' and '8' positions, the first substitution occurring in 6-position (cf. Parekh and Shah, *loc. cit.*, Sethna, Shah and Shah, *loc. cit.*).

Masking of the hydroxyl group by methylation, acetylation, etc., modifies the above noted effect. The carbon of methyl group, being not as ready to part with its electron as hydrogen of the hydroxyl, a methoxy group possesses less anionoid character than a hydroxyl. Hence the *para* directive effect becomes more predominant and *para* isomer is generally produced. Dey and Kutti's (*loc. cit.*) observations support this.

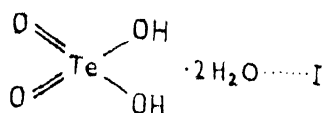
Also as Clayton (*loc. cit.*) observed, methyl group has significant influence in directing the entering groups. All other groups to a more or less degree influence the reactivity of a coumarin ring system. Groups, like CH_3 , NH_2 , OH , etc., exerting a negative inductive effect, increase the electron availability of all parts of the molecule and particularly in their neighbourhood. Hence such groups increase the speed of substitution. Conversely groups, like NO_2 , CN , SO_3H , COOH , etc., exerting positive inductive effect, decrease the electron availability of the molecule, thus rendering substitution more difficult.

The above electronic explanation of the reactivity of the coumarin ring system, so far as it goes, is sufficiently comprehensive to deal with all the reactions so far investigated.

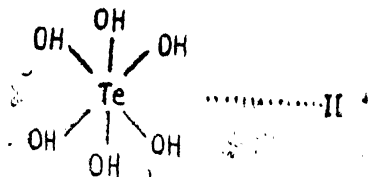
MAGNETIC STUDY OF THE MOLECULAR CONSTITUTION OF SOME TELLURATES

By S. S. DHARMATTI AND C. R. KANEKAR

FROM the analogy of the constitution of sulphuric acid, telluric acid dihydrate should have the following constitution:



Prasad and Dharmatti⁽¹⁾ have measured the magnetic susceptibility of telluric acid dihydrate and have arrived at the conclusion that the two molecules of water of crystallisation in the acid are constitutional and hence the constitution of the hydrated telluric acid is the one suggested by Gutbier⁽²⁾



It will be observed that the experimental value of the susceptibility of the acid is lower than the one calculated for the constitution suggested by Gutbier.⁽²⁾ This difference has been attributed to the strong ionic binding of the water of crystallisation in the acid hydrate.

In the present investigation, the susceptibilities of sodium and ammonium tellurates have been measured by the authors and their constitutions have been discussed in the light of the conclusions arrived at in the case of telluric acid.

EXPERIMENTAL

The susceptibilities of the tellurates were measured by a modified form of Guoy's balance by the same method as employed by Prasad and co-workers (3). The tellurates were obtained from Dr. Theodor Schuchardt's laboratories and were guaranteed pure.

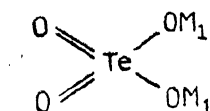
The results obtained are given in Table I in which χ_a and χ_m represent, respectively, the specific and the molecular susceptibilities. In all cases the values obtained are the mean of three independent and closely agreeing readings. All values of the susceptibilities have been expressed in the unit of 1×10^{-6} .

TABLE I

Substance	χ_a	χ_m
$(\text{NH}_4)_2 \text{TeO}_4$	0.3511	80.15
$\text{Na}_2 \text{TeO}_4 \cdot 2\text{H}_2\text{O}$	0.3332	91.16

DISCUSSION OF THE RESULTS

On the analogy with sulphates, the constitution of tellurates can be represented as



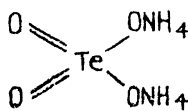
where M_1 stands for a monovalent ion, and the water of crystallisation does not enter into the constitution. Values of the molecular susceptibilities were calculated for the two tellurates for the above constitution and were compared with the experimental ones. The susceptibility value used for the hexavalent tellurium in these calculations is calculated according to Slater's method. Slater's value (13.15) has been used for the double bond oxygen and Pascal's value (4.61) for the other two oxygen atoms. Stoner's (4) value (12.0) is used for the ammonium ion and 7.31, which is a mean of the several reported values, for the sodium ion. The results obtained are given in the following table.

TABLE II

Substance	χ_m calculated	χ_m Experimental
$(\text{NH}_4)_2 \text{TeO}_4$	77.33	80.15
$\text{Na}_2 \text{TeO}_4 \cdot 2\text{H}_2\text{O}$	93.87	91.16

(a) AMMONIUM TELLURATE $(\text{NH}_4)_2 \text{TeO}_4$

It will be seen that the experimental value obtained for ammonium tellurate agrees fairly well with the calculated value. This indicates that (1) the constitution of ammonium tellurate is



and (2) the binding between the double bond oxygen and hexavalent tellurium is weak.

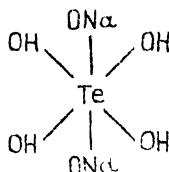
According to the additivity law, the susceptibility of the telluric acid dihydrate is given by

$$\chi_{\text{H}_2\text{TeO}_4 \cdot 2\text{H}_2\text{O}} = 2\chi_{\text{H}_4} + 2\chi_{\text{H}_2\text{O}} + \chi_{\text{TeO}_4}.$$

Therefore, the value of the susceptibility of the tellurate ion can be derived by subtracting the values of the susceptibility of 2 molecules of water of crystallisation and of 2 hydrogen ions from the molecular susceptibility of the acid. The value thus obtained is 25.77. The susceptibility of ammonium tellurate will then be 49.77 being the sum of 25.77 and 24.0 (twice the susceptibility of the ammonium ion). This is very much lower than the experimental value and hence indicates that the constitution of ammonium tellurate is different from that of telluric acid dihydrate.

(b) SODIUM TELLURATE DIHYDRATE ($\text{Na}_2\text{TeO}_4 \cdot 2\text{H}_2\text{O}$)

The study of sodium tellurate dihydrate is rather interesting. On usual considerations, one expects that its constitution should be similar to that of the ammonium salt. However, it is likely that the influence of the metallic radical sodium on the constitution of sodium tellurate may be different from that of the non-metallic ammonium radical in ammonium tellurate. Besides, sodium tellurate is a hydrated salt while the ammonium tellurate is an anhydrous one, hence the association of two molecules of water of crystallisation with the sodium tellurate molecule may assign to it a constitution similar to the one proposed by Gutbier for telluric acid dihydrate. However, the good agreement between the calculated and the experimental values (Table II) indicates that (1) the constitution of sodium tellurate is the same as that of the ammonium salt and (2) the double bond oxygen atoms are linked loosely to the hexavalent tellurium, and (3) the molecules of water of crystallisation in the sodium salt are loosely held and hence they bring about no serious departure from Pascal's additivity law. This shows that the constitution of sodium tellurate dihydrate cannot be represented as



The justification of this conclusion is shown further by calculating the susceptibility of sodium tellurate for the above constitution, taking the susceptibility of OH ion to be 7.54 and all the other values the same as used in the previous calculations. The value thus obtained is 71.81 which is much lower than the experimental value. Further, if sodium tellurate has the same constitution as telluric acid, one can calculate

within reasonable limits, the value of the susceptibility of sodium tellurate dihydrate from the observed molecular susceptibility of telluric acid dihydrate as follows : —

$$\chi_{\text{Na}_2\text{TeO}_4 \cdot 2\text{H}_2\text{O}} = \chi_{\text{H}_2\text{TeO}_4 \cdot 2\text{H}_2\text{O}} + 2\chi_{\text{Na}^+} - 2\chi_{\text{H}^+}$$

$$= 57.55 + 2(7.31) - 2(2.93)$$

$$= 66.31$$

This value is again far lower than the experimental value. These calculations therefore lead to the conclusion that the constitution of sodium tellurate dihydrate is different from that of telluric acid dihydrate.

IONIC SUSCEPTIBILITY OF TeO_4^{2-}

It is possible to determine an average value of the susceptibility of the tellurate ion, by subtracting all the values for the cations reported in the literature from the observed molecular susceptibilities of sodium and ammonium tellurates, and taking a mean of all the values thus obtained. The results of these calculations are shown in Table III.

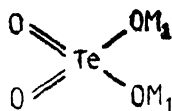
TABLE III

Authors for Value of χ_{cation}	χ_{cation}	$\chi_{\text{TeO}_4^{2-}}$
$\chi_{\text{mNa}_2\text{TeO}_4} = 65.24$		
Abonnenc	5.4	54.44
Brindley	5.2	54.84
Flordal & Frivold	6.9	51.44
Hoare & Brindley	6.1	53.04
Int. Crit. Tables	9.2	46.84
Ikenmeyer	10.4	44.44
Kido	7.0	51.24
Kido	7.6	50.04
Weiss	8.6	49.24
$\chi_{\text{m}(\text{NH}_4)_2\text{TeO}_4} = 80.15$		
Kido	12.4	55.35
Stoner	12.6	56.15
Trew	13.3	53.55

The mean value for the susceptibility of TeO_4^{2-} is 51.72. The value for $\chi_{\text{TeO}_4^{2-}}$ can also be calculated by using Slater's value for the double bond oxygen, Pascal's value for single bond oxygen and values calculated for hexavalent tellurium according to Slater's method. This comes out to be 53.33 which is in good agreement with the average value mentioned above.

SUMMARY

The constitutions of sodium and ammonium tellurates have been determined by a comparison of their observed molecular susceptibilities with the computed ones. It has been established that both the tellurates have the same constitution represented by



6

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SPECTROSCOPY IN INDUSTRY*

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IT is now generally acknowledged that spectroscopy is the most wonderful single scientific instrument. The premier position assigned at one time to microscope is now held by spectroscopy. While advances in the science of electronics have contributed to the evolution of a more powerful instrument in electron microscope, the spectroscopy is still continuing in its position of honour.

Numerous achievements are attributed to the science of spectroscopy ever since the discovery of the composite nature of light by Newton in the year 1666. Since then the theories of light have undergone revolutionary changes, but the basic principles of obtaining a spectrum have not altered much. The modern spectroscopy contains such optical parts as give definition of the spectrum, light-gathering power and resolution. Perfection in the production of spectral instruments has been attained as a result of progressive mechanical devices of modern age. . .

The pioneer work of Newton and later of Fraunhofer found no immediate application. The subsequent period of about a century was practically unproductive. Not until 19th century, the subject began to assume some significance. In the year 1822 the methods of spectrum analysis were first adopted by Herschel and these contributed greatly to the development of chemical science. The differences noticed in the spectra of different elements or compounds served a guide to the identification of their special characteristics. Chemists and physicists thus got a clue to the discovery of new elements.

Sir William Ramsay recognised rare gases of the atmosphere by the novelty of their spectra. Among these we have neon to which we are indebted for our neon signs industry, argon for the gas-filled lamps and krypton and xenon gases. Most important of all is helium so wonderful and useful for our dirigibles and strato-balloons. Papers of those days said that this mysterious, bouyant gas was argon, but they could not fool the spectroscopy.

Then followed the discoveries of elements rubidium and cesium in 1860, thallium by Crookes in 1861, indium by Reich and Richter in the year 1863 and gallium in 1875. Bunsen and Kirchhoff found spectroscopy such a magical instrument that it disclosed to them minute impurities in supposedly clean substances. With this sensitive device in their possession, "they were almost haunted by the idea of a dirty

* Read in abstract at the Symposium of the Indian Science Congress, Delhi, 1947, on the subject of "Place of Physics in the Economic Development of India."

world around them. Their faithful companion could track down tiny particles or substances in most unexpected places like a police dog picking up the scent-tracks down a fleeing animal."

But this is an old story. To quote a more modern example we are indebted to Urey and his collaborators for the discovery of deuterium (heavy hydrogen), a constituent of heavy water by purely spectral methods and confirmed later by other methods. This isotope now plays an important part in the development of atomic energy.

Though spectrum analysis had become possible and demonstrated its utility, it was not seriously taken up as a practice in the years following the major discoveries, owing to apparent caprices of the method and the then imperfect state of physical and chemical knowledge, chemists, in fact, soon abandoned it. For the next few years probably a decade, it was kept alive and in some degree, developed by astronomers for whom no other means of investigation were available. This was just prior to Bohr's theory of 1913. But subsequent to this, spectroscopy stood in the forefront of atomic physics.

Years of sustained research and investigations on atomic physics brought the rebirth of applied spectroscopy. The latter, however, did not stop the purely academic pursuits in the subject. As these progressed a large amount of data empirical or otherwise accumulated, which in some measure led to the elucidation of the structure of matter in the solid, liquid and gaseous state. Spectra are classified in two main divisions: emission and absorption, and it is by these that investigations have given both qualitative and quantitative results. Problem of quantitative spectrum analysis can now be regarded as solved, but considerable experience not always possessed by authors of published analyses is necessary for reliable results. Varied types of spectral instruments have been employed keeping in view the object to be achieved and the spectral region to be investigated. Quartz spectrograph is a common instrument, the region being mostly visible and u. v. It allows both emission and absorption spectra to be investigated. Lately G. R. Harrison has advocated the use of grating. Besides u. v. and visible portions, the infra-red with its vast extent has of late, assumed great importance. It is not the object of this article to describe the details of spectral technique, but to state in what way it has contributed to the solution of diverse problems of industry. The quantitative aspect being kept in view, some form of photometer or photometric device is always used in conjunction with the spectral instruments, giving them the character of spectrophotometers. Though photo-electric methods are used in several places, photographic plate will retain a trustworthy place for years to come. The practice of the art and science of spectroscopy depends on one's familiarity with the technique and experience gained in reliability and repeatability of the results. Spectrophotometry is now a regular feature in many departments of noted industrial and research establishments.

The method of spectral analysis is capable of measuring minute quantities of substances to the extent of even 1 part in a million. It has advantages over chemical method for the following reasons: (i) the given sample is generally too small to be examined by chemical means, (ii) spectroscopic examination can give all constituents at a time in a

single sample, while chemical analysis requires separate examination by portions of the material, (iii) spectroscopic examination can be made much more quickly than chemical analysis with accuracy and sensitiveness not attainable by chemical means. According to Twyman in a statement made in 1944, the number of spectral analyses of minerals and alloys in Great Britain may run into millions each year.

In what follows I shall indicate the manner in which analytical and industrial problems and processes have been subjected to the methods of spectroscopy. The general classification is under the following main heads :

I. Analytical; II. Industrial; III. Bio-chemistry and Physiology; IV. Miscellaneous.

Each of the above can again be divided into sections as under :

I. ANALYTICAL

1. General, 2. Applications to colorimetry, 3. Inorganic chemistry, 4. Organic chemistry, 5. Infra-red applications, 6. pH measurements, 7. Chemical equilibria and reactions.

II. INDUSTRIAL

1. Chemical warfare, 2. Colloids and metallic films, 3. Colour analysis and measurement, 4. Dyestuffs and textiles, 5. Electrical materials industry, 6. Foodstuffs and fermentation industry, 7. Glasses and galzes, 8. Hydrocarbons, fuels and minerals, 9. Iron and steel, 10. Leather, 11. Non-ferrous metals, 12. Oils, fats and soaps, 13. Paints and pigments, 14. Paper and cellulose, 15. Photo materials and photography, 16. Printing inks, 17. Resins, 18. Rubber, 19. Sugar and starches.

III. BIO-CHEMISTRY AND PHYSIOLOGY

1. Terpenes and essential oils, 2. Purine derivatives, 3. Alkaloids, 4. Natural colouring agents, 5. Plant physiology, 6. Vitamins, 7. Steroid and Hormones, 8. Proteins, 9. Enzymes, 10. Physiology and pathology.

IV. MISCELLANEOUS

1. Criminology, 2. Ceramics, 3. Agriculture, 4. Archaeology, etc.

The above list is not supposed to be comprehensive, but it gives ideas of the applications of spectroscopy to varied problems. Thus, not only industrialists, but astronomers, biologists, chemists, geologists, metallurgists, physicists and physicists find the technique of spectroscopy of great advantage, so much so, that rapid development of analytical method seems assured for years to come.

A particular reference need be made here to hydro-carbons, fuels and their combustion as that happens to be our line of investigation at these laboratories for some time. Notes on bearing of spectroscopy on other industrial problems will then be added.

Gaydon aptly differentiates combustion from the ordinary chemical reaction by the appearance of flame, i.e. emission of light. Prof. Egerton of the Chemical Technology Dept. of the Imperial College of Science and Technology, in a preface to a recent publication, says—"...the history of the progress of chemistry is knit closely with the study of combustion..." and these phenomena have been interpreted in terms of chain reactions. In flames the reactions are running fast and measurements of the kind which provide valuable information about slow oxidation cannot be made. The spectroscope can, however, reveal some of the constituents of flames, howsoever fast the reactions may be and can in many cases provide quantitative information about them.

Identification of the character of radiation from flames is to be traced to the systematisation of molecular spectra during the years 1920 to 1930. In combustion process many radicals whose existence was unknown before were noticed and assigned to definite emitters. Some idea of the application of these observations to the study of chemical reactions can be had from the special treatises on combustion, such as Bone and Townsend's "Flames and Combustions in Gases," Herzberg's "Molecular Spectra and Molecular Structure" and Gaydon's "Spectroscopy and Combustion Theory."

On the applied side the most important problem that awaits solution in any industrial country is the problem of fuels. At present coal and oil are the two most important fuels. India is not very rich in coal and is decidedly very poor in the matter of mineral oils. The most fundamental point for investigation is the examination of these fuels as to their suitability in internal combustion engines. Very many problems will be solved if one knows how exactly the fuel burns. If the exact process of combustion of fuels in engines is determined, one could then formulate the conditions which ought to be satisfied by a good fuel. With a view to ascertain such process, certain fundamental research is necessary. As a preliminary, flames of simple fuel gases; such as ethylene, methane, acetylene, ethyl alcohol, methyl alcohol with others on the programme have been chosen. Taking for instance, ethylene and mixing it in variable percentages with air, we pass by gradual stages from very lean to very rich mixtures and the resulting flame shows changes in its spectral character. The latter gives unfailing evidence of intermediate products. Free radicals such as C_2 , CH , OH are found and their relative abundance is susceptible to richness or leanness of the fuel mixture. Much qualitative work is done so far, but quantitative data is indispensable for interpretation of combustion mechanism. Such results obtained for processes in reaction zones of oxycoal-gas flames in our laboratory, have amply confirmed the conclusions of Lewis and von Elbe from non-spectroscopic methods pursued by them in the Coal Research Laboratory of the Carnegie Institute of Technology.

In other directions the study of flames can be tackled by the study of spectral continuum in the inner and outer flame cones as done by Gaydon at the Imperial College of Science and Technology. Its presence or otherwise in certain flames is taken as evidence for the view that an energetic oxygen molecule combines with energetic hydro-carbon molecule to form a temporary peroxide. This peroxide breaks down further into aldehyde and water setting free energy to maintain combustion. Such work and the work already done by us give promise of very valuable

information and consequently the problem of combustion by spectral methods is being attacked in our laboratories from several angles. It is assuming greater importance in India in view of the plans for Internal Combustion Engines Research and the establishment of the Fuel Research Institute at Dhanbad, where short-range and long-range programme of research in fundamental, scientific and industrial problems is planned.

The way in which other industries can derive benefits from spectroscopic investigations is briefly indicated below :

CHEMICAL WARFARE : In the production of the chemical warfare materials, the problems of tear gases, lung and nose irritants, skin poison, etc. arise and they can be solved by both qualitative and quantitative methods of analysis.

COLOUR ANALYSIS AND MEASUREMENTS : Colour standards have been devised based on spectral curves. There is the I. C. I. 1931 standard observer and co-ordinate system of colorimetry which provides data for the calculation of numerical specimens of colour for definite illumination.

DYESTUFFS AND TEXTILES : A recording spectrophotometer records measurements on coloured specimens giving graphic relations between colouring processes and physical colour properties—a process called “matching.” Rapid determination of visual properties is done by mechanical intergraph.

ELECTRICAL INDUSTRY : Spectral characteristics are studied for material for light sources, insulating media, filters for theatrical lighting and high intensity mercury lamps in lamp industry. British Insulated Cables Co., Ltd. carries out regular tests for connection between the electrical and optical properties of plastic films, cellulose derivatives and so on.

FOOD AND FERMENTATION INDUSTRY : In the “doctoring” of jams detecting presence of small amounts of benzoic acid, the adulteration of honey, butter, margarine, cream, etc., effect of heat on saccharine, estimation of carotenoids, vitamin A in eggs and milk, colouring of food-stuffs, adulteration of wine in fruit-juices, artificial colouring of wines, beer and brewing products.

GLASSES AND GLAZES : Problems of composition of glass, colouration, staining and transmission, analysis of glasses and glazes. The American Rail Road Association uses spectral transmission curves of standard glasses for specifying the signal glasses.

CERAMICS : Ambition of many artists in this field is to reproduce the highly talked of glazed pottery of the old Grecian artists. Chemical analysis failed to establish the composition of the thin black pigment by them. Spectral methods are being used.

IRON AND STEEL : Here there is always need for analysis of such rapidity that it should provide production control rather than simply inspection of finished product. The spectrophotometric installation at Ford Motor Co. handles efficiently about 300 samples per 16-hour day, the maximum time between receipt of sample and posting of analysis being 6 minutes.

At the U. S. Naval Torpedo Station, ordnance supplies and material, nickel and its alloys, brasses, steels, etc. are tested and controlled spectroscopically.

DIE-CASTING ALLOYS : Spectrographic method is the most reliable method for control of quality in the manufacture and use of die-casting alloys.

ELECTRO-PLATING : Spectrograph aids in checking the composition of solution and detecting the presence of harmful impurities.

LEATHER INDUSTRY : The tanning extracts and mechanism of tanning processes are studied.

OILS, FATS AND SOAPS : Absorption measurements are used for colour characteristics and grading of vegetable, and fatty oils. Routine tests become necessary in many operations.

PAINTS AND PIGMENTS : The problem of permanence of paint, artists' pigment, enamel coating and various other paint materials are resolvable in terms of spectrophotometric reflectance.

PAPERS AND PULP : Problems of shade and composition are solved in terms of reflectance, absorption and scattering. The same technique allows for investigation of the quality grading, transparency and bleaching and dyeing.

PRINTING INKS : In the control of production and quality of printing inks and the applications of the latter in the field of process colour printing.

RUBBER : The processes in the preparation of synthetic rubber and the mechanism of stretching can be well studied by absorption spectra. Helps to distinguish old rubber from new material.

RESINS : Ultra-violet transmission is obtained for studying the effect of u. v. light on resins used in cementing together glass sheets in the manufacture of splinter-proof glass.

SUGARS AND STARCHES : The International Sugar Commission for uniform methods of sugar analysis has proposed spectrophotometry as the basis of all colorimetric measurements, quality grading of sugar and turbidity of sugar solutions in industrial process.

MINERALOGY : Examination of minerals from mines has stimulated search for new deposits. For example, the spectroscopic prospecting near Tin Mountain (Custer, South Dakota) has led to the discovery, in that vicinity, of new variety of mica.

MISCELLANEOUS APPLICATIONS

Among the miscellaneous applications, the spectroscope offers aid to criminologist in the police work where spectral analysis has led, in many cases, to positive results, as chemical methods could not be relied on for

confirmation. At the 6th Summer Conference on Spectroscopy in 1938, Mr. J. T. Walker of Massachusetts State Police has described a very interesting detection case utilizing spectroscopy.

Identification of organic and other poison and their detection even in very minute quantities in suspected food-poisoning, make spectroscopy a useful tool in toxicology. Application of emission spectroscopy to food-stuff industry is practised by Adam Hilger, Ltd., England.

Spectroscopy is of advantage in dental research. Flourine was identified as the cause of the disease known as "mottled enamel".

For survey work in the field, rapid spectroscopic methods of analysis are applied to mixed fertilizers of varying composition.

FLUORESCENCE ANALYSIS

In connection with this spectroscopic discussion, the technique of fluorescence analysis is of great interest also. The following are some of the useful applications :

In agriculture, for examination of fertilizers and distinguishing the varieties of wheat.

Bacterial contamination of different materials and for showing of cell structure in botany.

Testing the weathering of rocks, the products of silicate industry in construction materials and glass.

Examination of powders, solutions, greases, fats and oils in drug manufacture ; also various edible materials, such as, preservatives, eggs, spices and jams, etc.

For distinguishing various natural and artificial products in fuels and lubricants and tanning agents in tanning industry.

Scrutinising the body-marks, finger-prints, inks, seals and documents in police work.

Distinguishing the real and artificial gems, such as sapphires and pearls and detecting the spurious imitation.

Testing the authenticity of paintings in museums or fading and ageing in paints and varnishes.

CONCLUDING REMARKS

Such are the numerous scientific and industrial applications of spectroscopy. They need to be exploited for the technical progress of India in the post-war scientific and industrial development. Spectroscopist with trained spectroscopic personnel has a definite place in this expansion. Only then would the quality and standard of the

manufactured product be ensured and the industry prosper. Collaboration and personal contact between different workers in this line in the industrial and research establishments would be desirable and this can be brought about by periodical spectroscopic conferences as are held in America and England. These conferences can be arranged and organised by central scientific body through an expert committee of spectroscopists formed for the purpose. A recent example of such conference is the one held at London at the Imperial College of Science, in 1944, where besides discussion on applications of spectroscopy to science and industry, a representative group for the study of the subject was formed.

SUMMARY

One particular field of science whose research methods have permeated through a large number of industries is that of spectroscopy. Some of the important discoveries of chemical elements are attributed to this important branch of Physics. Methods of spectrum analysis are now well-known to many. They are capable of solving qualitative and quantitative problems in different industrial processes and operations.

The modern methods of spectrum analysis for both qualitative and quantitative purposes are set forth in the article stating the advantages and disadvantages of the different forms of the technique for rapid reliability and repeatability of results. The extent to which the spectral analysis measures very minute quantities and its efficacy in relation to chemical methods are briefly indicated. In the year 1944 alone in Britain, the number of spectral analysis of mineral alloys runs into millions.

The analytical and industrial problems subjected to methods of spectroscopy are classified. They give an idea as to how industrialists, biologists, chemists, geologists, metallurgists, physicians, meteorologists, physicists and others find the technique of spectroscopy very useful and advantageous to their problems.

Particular reference is made to hydro-carbons, fuels and their combustion. Industrial applications of these problems occur in the derivation of energy from sources like internal combustion engines, flames, burners, stoves, etc. Such investigations form a regular feature in special laboratories established for the purpose, like the Coal Research Laboratory of the Carnegie Institute of Technology, U. S. A.

The article also deals with details of many other industrial applications, in which spectroscopy plays a prominent part.

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"BARISAL GUNS" AND THE UPPER ATMOSPHERE

BY DR. M. W. CHIPLONKAR, D.Sc.

INTRODUCTION

THE propagation of sound waves produced by violent explosion through the atmosphere was discussed as early as 1904 by Van d. Borne. He gave an explanation of the peculiar distribution of audibility of sound around the source based on its reflection downwards at some high levels in the atmosphere. The problem was later investigated experimentally by Hergesell and Duckert¹, Gutenberg², Bendorff³, Whipple⁴, and others⁵, in Europe and Polar regions who arranged special explosions to produce the sound waves and recorded them aurally or with self-recording instruments well distributed over the surrounding country. These observations could be utilised to give very valuable information regarding the physical state of the upper atmospheric layers lying beyond the reach of sounding balloons. Excellent summaries of these various investigations will be found in the following publications: (1) *Lehrbuch der Physik*, (1928)⁶, (2) *Proceedings of the Royal Meteorological Society*, (1935), Symons Memorial Lecture⁷, and (3) *Zeitschrift für Geophysik*, (1934), the Special number.⁸

THE BARISAL GUNS

The author in the course of his investigations, while going through the old literature, came across a very interesting and important publication entitled "Memorandum on the Barisal Guns" by Lt.-Col. Waterhouse.⁸ "Barisal Guns"⁹ are loud explosive sounds very similar to the firing of distant guns. They are very often heard at Barisal (marked B in Fig. 1) in South East Bengal and hence are known since long times as "Barisal Guns." After giving a detailed account of the numerous observations, special and casual, made by various people, at various times and places in Bengal and Assam he discusses all the then existing theories about the origin of these peculiar sounds. The main aim of the present communication is to show on the one hand, that from a careful examination of the various reports it is easy to explain all the observed peculiarities of the phenomenon on the hypothesis referred to in the introduction above, *viz.* the reflection of sound waves in the upper atmosphere, and on the other, to point to "the swash of no ground" as the only possible place of origin of these sounds. The latter point was, in fact, put forward by some of the older observers but in the memorandum it was dismissed as improbable for want of convincing evidence in its favour.

Before proceeding further it is worthwhile bringing together the different significant facts of observation mentioned in the memorandum and also in the various other papers which came after it as given below :—

(i) The genuineness of the phenomenon is proved beyond doubt by the fact that about two dozen authors have narrated it from their own personal experiences some extending over several years and also numerous reliable local inhabitants in different parts of Bengal and Assam have corroborated the details from their still longer experiences.

(ii) The sounds are heard mostly in the hot season and the monsoon (from March to September) especially just before and after the rains. It was reported only once in the cold season.

(iii) They are heard at all times of the day and night but predominantly at night and in the quiet hours of the morning and the evening. They are rarely heard during the noon hours.

(iv) The sounds are heard as single explosions or in quick succession, the interval varying from some seconds to 2-3 minutes at different places. At times they have continued for several hours at random.

(v) (a) They are heard at most of the places in the deltaic region between the rivers Hoogli and Meghna up to Dacca and Fureedpur to the north and Tiger Point, Chapli Chur and Kukri Mukri to the south.

(b) They are never heard at Maldah, Nadiya, north of Dacca and Fureedpur and in the south at Balasore Rangpur (south of Calcutta) and some points of Sunderbans.

(c) They are again heard at such great distances as Cheerapunjee, the south west parts of Garo Hills, especially very distinctly at Mohendragunj, and also as far as Jalpaiguri.⁹

(vi) At all these places (a) and (c) the sounds are always heard from the south, south-west or south-east. It was reported to have been heard only once from the north and once from north-west.

INTERPRETATION

Fig. 1 shows the map of North-East India and a part of the neighbouring Bay. The different places from which reliable reports have been gathered are marked on it; the positive sign representing audibility and the negative sign inaudibility of these sounds. Of course, it must clearly be borne in mind while interpreting them that they do not represent simultaneous observations nor do they perhaps refer to the same point source or origin of these sounds nor to the same single explosion. In a way they can be taken to represent an unbiased statistical data obtained in a perfectly random manner, particularly because it was compiled at a time when the idea of the excursions of sound waves through the upper atmosphere and the consequent production of alternate zones of audibility and inaudibility was not even dreamt of. As mentioned before, however, the information when brought together as shown in Fig. 1 lends itself to easy interpretation in the light of the modern ideas about the upper atmosphere. Referring to Fig. 1 and (vi) above the source of sound waves can only be located somewhere out in the Bay in the region called “the swash of no ground.” The negative observations in some parts of

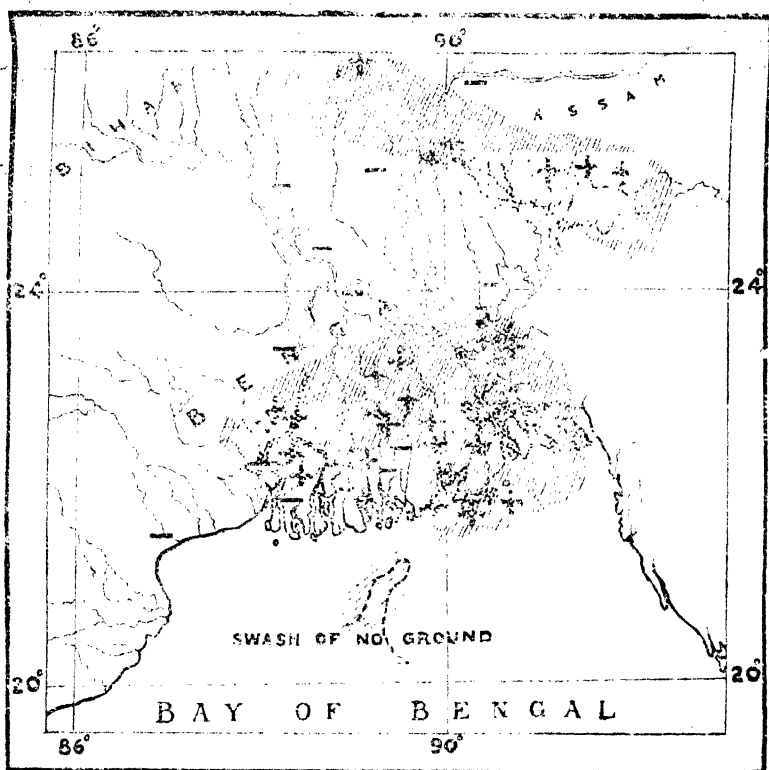


FIG. 1

the Sunderbans shew that the first zone of audibility stretches only over the neighbouring area ; and consequently the first zone of silence lies partly over the western half of the Sunderbans. The second zone of audibility (larger shaded area in Fig. 1) extends over the deltaic region lying between the rivers Hoogli and Meghna. Next the second zone of silence or inaudibility stretches across the country lying between Dacca and Cheraipunjee in the east and between Balasore and Nadiya and Maldah in the west. The third zone of audibility (smaller hatched area in Fig. 1) extends from Jalpaiguri, over the Garo Hills to Cheraipunjee and beyond. The zones are not complete rings surrounding the origin because the source itself lies far out in the Bay and therefore similar observations are not available to extend them on other sides. Moreover the winds in the upper atmosphere during the period of observation (March—September) in these latitudes must also have had their distorting effect on the shape of these zones especially in extending them more towards the north-east than towards the north-west, or west.

DISCUSSION AND CONCLUSIONS

The three curves in Fig. 2 show the average distribution of temperature in the upper atmosphere over the temperate region (W and D) and the tropics (C). The former two are based on the sounding balloon

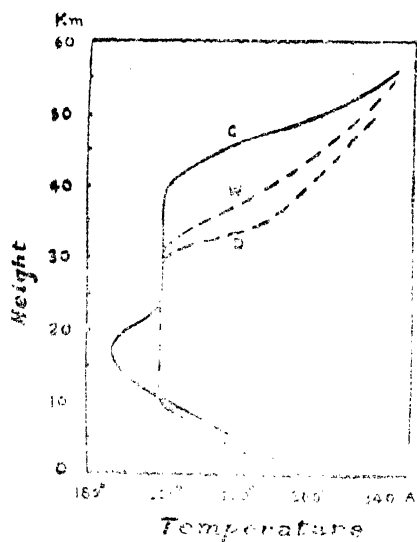


FIG. 2

ascents in Europe upto 25-30 Km. level and above that on the results of explosion experiments mentioned before. The latter (curve C) is based on the sounding balloon ascents at Poona (Lat. $18^{\circ} \cdot 5$, Long. $73^{\circ} \cdot 9$) upto a height of 35 Km.^{10, 11}, and above that on the interpretation of the data of "the Barisal Guns." For this purpose the following plausible assumption have been made :—(1) that the sound ray is almost horizontal both at the source and at the place of observation, (2) the average interval between two successive sounds is taken to be 120 seconds and more (3) that for approximate calculations average values of the velocity of sound may be used, (4) that the disturbing influences such as the winds in the upper atmosphere, the variation in the temperature distribution in the upper atmosphere over the region, etc. are not considered ; thus making the upward sound ray track symmetrical and identical in length, with its downward track. The main points of differences between the distributions may be noted thus :—

- 1) The Tropical Tropopause, as is well known, colder and much higher than that of the higher latitudes.
- 2) There is a well marked region of negative lapse rates at the base of the stratosphere, which is practically absent in the case of the higher latitudes.
- 3) In the tropics the isothermal region begins at a higher (25 Km.) level and also persists upto higher (35-37 Km.) levels.
- 4) The final region of negative lapse rates and high temperatures begins at higher levels (above 40 Km.) and extends upto 55-60 Km.

These differences give rise to the following consequences :—

(A) Because of the greater differences of temperature at the surface and the tropopause in these latitudes, the sound waves proceeding practically horizontally at the ground enter the base of the stratosphere making the (smallest) angle of about $37^{\circ}18'$ as against $29^{\circ}53'$ of the temperate latitudes. Apart from other causes such as the reduction in the average velocity of sound waves due to lower temperatures in the upper atmosphere over the tropics this also produces an increase in the total length of the path of sound waves entering the stratosphere and hence delay to a greater extent their arrival in the second zone of audibility.

(B) In the tropics the sound waves soar up to higher levels before they are finally turned round to start on their downward journey. This also augments the total length of their paths.

(C) The region of negative lapse rates at the base of the stratosphere has no other significant influence on the path of the sound waves except that mentioned in (A). In particular, contrary to expectation, there does not exist even the possibility of multiple reflections—correctly speaking multiple recurving—occurring in the region of the atmosphere extending from say, 12 Km. to 25 Km. since the recurvature of the sound ray towards the ground occurring between 17 Km. and 25 Km. levels taking even the most favourable temperature distribution recorded till now, is only 25° which is much smaller than 37° - 38° required for the phenomenon to occur.

It has been reported by many that occasionally the loudness of these sounds is sufficient to wake up one from sleep ! It is not therefore, quite clear how such enormous energies could be retained by the waves that have travelled to such great distances.

In conclusion it may be mentioned here that although this collected data has given valuable information much needed since long^{10, 11} it is essential to carry out special investigations in these latitudes, on the lines of the European workers and to see how far they bear out the above conclusions. It will also be worth while keeping a fresh record of the Barisal Guns at various places in Bengal and Assam and the neighbouring regions with a view to study it further and to ascertain its exact cause.

SUMMARY

Attention is drawn to an old publication of (1888) entitled "Memorandum on the Barisal Guns" and other similar papers which give a good deal of information on the nature and distribution in time and space of the loud sounds well known since long as "Barisal Guns." From the existence of the alternate zones of audibility and inaudibility and the direction of sound waves, etc. it is inferred that the place of origin of these sound waves lies in the so-called "Swash of no ground" in the Bay of Bengal. On the basis of the excursions of sound waves through the upper atmosphere and the dependence of velocity of sound on temperature an approximate distribution of temperature in the stratosphere over the tropics is deduced and compared with those obtained by others in the temperate latitudes. This, therefore, furnishes a reliable

statistical data which gives for the first time this temperature distribution over the tropics. It is, however, stressed that further explosion experiments be carried out in these latitudes to verify the conclusions arrived at here.

[January 1946]

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ABSTRACTS OF THESES

*Summaries of the Theses Submitted for the M.Sc. Degree (1945)
in Chemistry to the Bombay University*

Studies in Fats and Related Topics

By MR. G. M. KULKAR, S. P. COLLEGE, POONA 2

SECTION I: *An Examination of the Enzyme and Inorganic Constituents of the Seeds of Hygrophila Spinosa.*

The inorganic constituents of the seeds of *Hygrophila spinosa* have been determined. The seeds are found to contain: P_2O_5 (2.1%), K_2O (3.3%), Fe_2O_3 (0.42%) and CaO (0.049%). Detection of the enzymes in the seeds has shown the presence of diastase, lipase and protease. The seeds contain 30.7% digestible proteins. It is suggested that these constituents are responsible for the therapeutic value of the seeds.

SECTION II: *Chemical Investigation of the Seeds of Argyria Speciosa (N. O. Convolvulaceae).*

The seeds of *Argyria speciosa* have been subjected to a thorough chemical investigation. The ash of the seeds contain: P_2O_5 (27.9%), K_2O (61.4%), MgO (6.63%) and CaO (3.12%). The presence of diastase in the seeds has been proved. The seeds give a fatty oil which has been found to contain the glycerides of palmitic (6.73%), stearic (29.12%), behenic (6.64%), linolenic (6.09%), linolic (18.17%) and oleic (33.23%) acids. An alkaloid has been detected in the seeds.

SECTION III: *Chemical Investigation of the Seeds of Ipomoea Muricata (N. O. Convolvulaceae).*

The seeds of *Ipomoea muricata* on extraction with ether gave a fatty oil (8.7%). The component acids of the fatty oil have been shown to be: palmitic acid (13.6%), stearic acid (22.5%), behenic acid (3.78%), linolenic acid (3.9%), linolic acid (15.15%), and oleic acid (40.97%). The composition of the seed fats of *Argyria speciosa*, *Ipomoea muricata* and *Cuscuta reflexa* have been compared. The presence of behenic acid in the seed fats of the natural order Convolvulaceae has been proved for the first time. The seeds are found to contain an alkaloid (m. p. 208°) which gives a picrate (m. p. 103°).

SECTION IV: *A Study of the Frog Depot Fat.*

The frog depot fat has been analysed and the presence of myristic acid, palmitic acid and also hexoic, octoic and decaic acids as solid acids and morotic acid and oleic acid as liquid acids has been proved. The presence of octa-deca-tetra-enoic (morotic) acid and C_{25} to C_{31} lower saturated acids is remarkable. The results are compared with those obtained by Klenk (Z. Physiol. Chem., 222, 264, 1933).

PART II—*Attempted Synthesis of Methyl Decoic Acids.*

Outlines of the attempted methods of synthesising isomeric methyl decoic acids have been given. During the course of this work, the following new substances have been prepared:

- Ethyl-3-methyl-3-hydroxy nonanoate.
- Ethyl-3-methyl $\Delta^{2:3}$ -nonenoate.
- 3-methyl nonanoic acid (3-methyl pelargonic acid).
- 1-n-butyl-cyclohexan (1) ol.
- 1-n-butyl $\Delta^{1:2}$ -cyclohexane.
- 6-keto-9-methyl-decoic acid.

The difficulties in the work have been mentioned.

PART III—*Resolution of Diphenyl Glutaconic Acid.*

Diphenyl glutaconic acid has been resolved into d- and l-forms by the fractional precipitation of its strychnine salt. l-diphenyl glutaconic acid has m. p. 233-235° and ($[\alpha]_D = - (350)$) and d form has m. p. 233° and ($[\alpha]_D = + (106)$).

The dextro form has not been obtained in an optically pure condition. The acids could not be racemised by heating with hydrochloric acid or sodium hydroxide. Melting racemises the acids. Attempts to convert trans diphenyl glutaconic acid into its cis form according to the method of Feist (Ann. 370, 41, 1909) have been found to be unsuccessful.

Adsorption and Surface Tension in Relation to Toxicity

BY MR. M. R. PAI, S. P. COLLEGE, POONA 2

1. The previous work on the relation between physical properties and bactericidal power has been reviewed.
2. 4-n-alkyl salicylic acids, o and p-alkyl phenols and 4-n-alkyl resorcinols have been prepared and the methods of estimating dilute solutions of these compounds have been described.
3. The adsorption of 4-n-alkyl salicylic acids and p-alkyl phenols on activated sugar charcoal has been studied. It has been shown that the former conforms, more or less, to the Freundlich's equation only while the latter does not follow either Freundlich's or Langmuir's equation.
4. The adsorption by casein from aqueous solutions, the surface tensions and toxicity towards earthworms have been studied using for any given series, aqueous solutions of equimolar concentration.
5. It has been shown that there is no relation between toxicity and the ability of the members of a series to lower surface tension as also their adsorption by casein.
6. It has been shown that adsorption plays more important part in determining the toxicities of the higher members of the series while there is no correlation between toxicities and the adsorption from casein in the case of the lower members of the series. There is also no parallelism between the water solubilities of the compounds and their toxicities. It has been shown, therefore, that probably the mechanism of bactericidal action of the higher members of the series which are very sparingly soluble is quite different from the mechanism of bactericidal action of the more soluble lower members of the series.

Kinetics of the Reaction Between Aromatic Primary Amines and Esters of Aromatic Acids

BY MR. N. T. VARTAK, S. P. COLLEGE, POONA 2

1. The reaction between methyl esters of substituted benzoic acids and substituted anilines has been studied at various temperatures in nitrobenzene or xylene as solvents.
2. The reaction has been shown to be bimolecular and the velocity constant 'K', the activation energy 'E' and the probability factor 'P' have been calculated. The probability factor 'P' is practically the same for all the reactions.
3. A mechanism for the reaction has been proposed.
4. On the basis of the mechanism proposed the effect of substituents in benzoic acid on the reaction has been explained. The reactions belong to class 'B' type. The effect of substituents has been shown to be of the same type as the effect on the alkaline hydrolysis of esters and benzoylation of anilines.
5. The effect of substituents in the aniline molecule also follows the same order as the effect of substituents in methyl benzoate. This has been ascribed to the increased ionisation due to the presence of electronegative substituents. This effect is quite the reverse of that observed in the benzoylation of aniline.
6. The effect of 'CH₃' group in the ester molecule as well as in the aniline molecule is quite unexpected as it accelerates the reaction while on the basis of the mechanism proposed it should retard it.
7. In amyl alcohol and dioxan as solvents the reaction rate is considerably increased. Similar increase in reaction rates has been observed in the reaction between aniline and ethyl phenyl acetate too. This also supports the mechanism proposed as these solvents will help the ionisation of the base as is assumed in the proposed mechanism.
8. Three sets of curves representing o-, m-, and p- series of substituents have been obtained by plotting logK and dipole moments of substituted benzenes in accordance with the general relationship between reaction velocity and dipole moments discussed by Watson and co-workers (J. C. S., 1935, 1174). Here it has been found that the position of 'H' as substituent both in the esters as well as in the aniline is anomalous. It appears, therefore, that the abnormal character of CH₃ group is not really abnormal but the unsubstituted ester itself behaves abnormally.
9. In the meta and para series the treatment of Watson has been modified. By taking the effective moments of meta substituted compounds as $\mu \cos 60^\circ$, a curve is obtained representing both m and p substituted compounds and the relation comes out to be more general.
10. In the case of esters of benzoic acid with different alcohols the reaction has been shown to be faster with increase in carbon chain. The effect is almost entirely due to an increase in the probability factor.
11. Although at first sight the reaction appears to be similar in nature to the alkaline hydrolysis of esters and benzoylation of anilines the reaction follows at some stage a different mechanism.

NOTES AND NEWS

"SWORDS INTO PLOUGHSHARES"

IT was a wise decision on the part of the Council of the British Association for the Advancement of Science which held its first full-time post-war meeting in Dundee on August 27, 1947, to keep as the motto of that meeting the phrase "Swords into Ploughshares." The object of keeping this subject as a general theme for the meeting was to direct the thoughts of the members and of the sectional officers to the return of science to the service of peace from its abnormal concern with war from which it had just emerged. This was the note struck by Sir Henry Dale, in his Presidential address to the Dundee Meeting (*Nature*, August 30, 1947, p. 280), on "Science in War and Peace."

The period between 1939 and 1945, Sir Henry Dale remarked, was a period of great stress and strain for the scientists who were engaged in the solution of some of the important war problems but it was also a period of a great triumph for science in the service of war. That period again witnessed the best example of a very intimate collaboration of British and American scientists and engineers in their several investigations. Such a remarkable example of co-operative effort in research in teams was never known before even in peace times. This co-operative work in teams was done in different branches of science, physics, engineering, chemistry, biology, physiology, medicine, psychology, etc.

Naturally during war period the researches were mainly in the direction of applications of knowledge to the needs of the war. Sir Henry Dale therefore laid emphasis on the need of pure research and fundamental knowledge in the near future without in any way minimising the importance of applied research. Sir Henry Dale was also very emphatic on the necessity of the young budding scientists growing in an atmosphere of freedom, particularly in the Universities, and not as in war-time under a cramped atmosphere of military secrecy. The war period was an exceptional period and it was necessary to keep certain researches secret. The possibility of a Third War not being ruled out yet, a certain number of scientists working on war problems have still to work under a pledge of secrecy.

This practice of withholding certain secret knowledge from the profane was followed by the ancient Indian sages for it was supposed that if it was given out to anybody and everybody without discrimination it may not only harm the young inexperienced candidate for higher spiritual knowledge but also society. We now see that there may be some wisdom in thus withholding certain knowledge. The candidate had to prove his worthiness to receive such knowledge. Only when the teacher was thoroughly satisfied that his pupil would not misuse his knowledge for any personal ends for selfish purposes, but use it for the good of humanity, then only would he part with his secret to him.

The analogy is not perfect ; the two cases are not exactly parallel. In the case we are considering, the idea of keeping secret certain knowledge—say, for example, regarding the making of the Atom Bomb, is that the nation which has got this secret has the intention of using it for destroying the enemy nation or nations and is therefore careful that the secret does not go in the hands of the enemy to be used against it. In the case of the Guru and his disciple, the Guru would never dream of using his secret knowledge for any destructive purposes and his only aim in not revealing that knowledge to the unworthy is the good of the pupil and of society. The idea of withholding the secret from the unworthy is not with reference to ordinary knowledge which was of course the common property of all without any distinction.

* * *

There is a tendency among the lay people to blame science and scientists for the misuse of the forces given to the world by science. Neither science nor scientists who have made discoveries of these forces are to be blamed for any misuse of their discoveries. It is the users of these forces for a malevolent purpose who are to be blamed. That fact should not be forgotten. From this point of view, the news which the issue of *Nature* of August 30, 1947 (pp. 273-74) has brought of the formation of powerful 'anti-science' groups among some scholars and students is rather distressing. "They who should know better have been heard to express alarm at the march of science and demand the fettering of science and scientific workers." The only remedy against misuse of any knowledge is the refining and ennobling of man and improvement of his character. Scientists and educationists should direct their energies in this direction as to how best it could be done.*

D. D. KANGA

* In this connection, "Notes and News" in the following issues of the Physical Science Section of the *Bombay University Journal* may be read: Volume XII, Part III, November 1943; Volume XII, Part V, March 1944; Volume XIII, Part V, March 1945.

BOOK REVIEWS

Geology and Geography of Karachi and its Neighbourhood. By M. B. Pithawalla, D.Sc., F.G.S., and P. Martin-Kaye, R.A.F.

THE authors of the book under review have done a great service to the people of Sind and to all those interested in Sind and its problems by making available in the form of this monograph an excellent account of the Geology and Geography of Karachi and its neighbourhood.

The first part of the book gives an account of the Geology of the country and contains valuable information about its stratigraphy and its structural and economic Geology.

The second part dealing with the physical, economic and human geography of the area, contains a wealth of data regarding factors like the climate, the plant and animal life and the hydrography, and also some information about the existing conditions and the inherent potentialities of Karachi. It is difficult to appreciate a few of the authors' views, such as for example the one in the para quoted below :

"The geographical analysis given in the present monograph has showed us that some forces, far greater than we can imagine have been at work within the Karachi area and that there is some divine purpose for which the different communities have come together to settle in the City."

However, it may be stated that the authors have produced a monograph that will be found to be very useful to all those engaged in problems in connection with the future development of Sind.

Both the parts are fully illustrated and contain a large number of maps, sections, photographs and charts. There is, however, no index. The book may also serve as a guide to workers in other areas, by showing the methods a Geographer adopts in studying a country.

—K. V. KELKAR

The Chemical Activities of Bacteria. By E. F. Gale. University Tutorial Press Ltd., 1947.

THE book has been prepared on behalf of the Medical Research Council unit for Chemical Microbiology, University of Cambridge. It is a concise little treatise of about 200 pages and is divided into twelve chapters, each of which gives an account of a different phase of bacterial life and activity. In this book bacteria are considered as Chemical Agents and one gets an idea of their various activities, their enzymes, their growth and nutritional requirements for the synthesis of bacterial protoplasm and the formation of polysaccharides from a chemical standpoint. A description of the catabolic activities impresses one with the variety of chemical substances produced by the putrefactive and the fermentation changes effected by bacteria.

The arrangement of the chapters is well thought out and the book will prove useful to students beginning the study of bacteriology and biochemistry as well as to persons engaged in the fermentation industry. Students of pathology will be benefited by getting a clear grasp of the chemical activities of bacteria causing diseases in human beings.

The treatment of the subject in the book is elementary to some extent, but at the end of each chapter is given a bibliography, which will prove helpful to advanced students. To the research workers this book will serve as a short review of the background to research work which has already been carried out or which is being carried out at present on the chemical activities of bacteria. Research workers would have, however, appreciated original references to classical investigations or important papers some of which are not included in the book because of the limitation of references by the author to reviews and text-books. Had an account of the chemical activities of bacteria pathogenic to plants been included in the book, it would have proved very useful in comparing the activities of these organisms with those of human and animal pathogens.

—N. V. JOSHI

LIST OF THESES

Table showing M.Sc., M.Sc. (Tech.), Ph.D. and Ph.D. (Tech.) Theses in Physics, Chemistry, Geology and Textile Chemistry (from October 1946 to September 1947).

Name of the Candidate	Subject of the Thesis	Name of the Professor under whom the Candidate Worked	Name of the Institution
	M.Sc.		
	<i>Physics</i>		
Pathak, P. D.	The Measurement of Magnetic Susceptibility of Alkaline Halides and Landon Velocity of Sound in Liquid Helium II	Professor D. V. Gogate	B. C.
	<i>Chemistry</i>		
Ambegaokar, S. D.	Studies in Nicotinic Acid and Riboflavin Metabolism with special reference to Cancer	Dr. R. G. Chitre	Tata Memorial Hospital
Amin, G. C.	Studies in Fries Migration	Dr. N. M. Shah	G. C.
Behrana, J. S.	Influence of the Constitution of Dyestuffs on their Adsorption by Heat Treated (Insoluble) Gum Arabic	Professor C. S. Narwani	D. J. S.
Bhumwara, N. B.	Studies on Extraction of Cinchona Alkaloids	Professor M. L. Khorana	U.D.C.T.
Cooper, C. J.	A Few New Vat Dyes from a few Substituted Anthraquinones	Professor V. V. Nadkarny	St. X.
Dange, G. V.	Part I—The Preparation of Strontium Carbonate from Indian Celastite Ore by Metathesis with Sodium Carbonate; Part II—The Investigation on Plant and Wood Ashes for Commercial Potash	Dr. Mata Prasad	R. I. Sc.
Doshi, M. S.	Reaction between Mercuric Chloride and Nickel Hydroxide	Professor V. V. Nadkarny	St. X.
Desai, N. C.	Studies in the System $ZnSO_4-NaCl-H_2O$	Professor S. M. Mehta	R. I. Sc.
Gokhale, V. G.	Chemical Investigation of some Indigenous Plants	Professor B. V. Bhide	Sir P.
Jacob, Simon	Studies in Distillation	Dr. S. K. Bhattacharya	I. I. Sc.
Joshi, N. G.	Studies in Ascorbic Acid and Glutathione Metabolism in Cancer of Liver and Breast	Dr. R. G. Chitre	Tata Memorial Hospital
Kamat, V. N.	Adsorption of Basic Dyestuffs by Wool Fibre	Professor V. V. Nadkarny	St. X.

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Kansara, H. I.	Syntheses of Benzo-Pyrone Derivatives	Dr. N. M. Shah	G. C.
Karandikar, B. V.	The Reaction between Ammonium Sulphate and Bromine	Dr. V. K. Bhagwat	R. N. R.
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Khanolkar, D. D.	The Magnetic Susceptibilities of Lead Salts	Dr. Mata Prasad	R. I. Sc.
Kulkarni, V. S.	Part I—The Influence of an Acetyl Group in the 3-position on Reactions of Chromones, the Influence of an Acetyl Group in the 3-position on Fries Migration (by means of Anhydrons) Aluminium Chloride on Butyrate of 2-methyl-3-acetyl-7-hydroxy Chromone; Part II—Synthesis of 2 : 2 dimethyl 3'-ethyl Chromone 7 : 8 pyrone; Part III—Synthesis of 3-propyl-2' methyl 7 : 8'-fere Chromone; Part IV—A Comparative Study of Some Vegetable Ghees	Professor G. R. Kelkar	N. W. C.
Kunta, N. S.	Vat and Azoic Dyes Derived from some Derivatives of Phenanthrenequinone	Dr. R. D. Desai	U.D.C.T.
Kundel, R. H.	Studies in Synthetic Dyes	Dr. D. R. Desai	U.D.C.T.
Merchant, J. R.	Interaction of Thionyl Chloride and Hydroxy Acetophenones and their Derivatives in Presence of Finely Divided Copper	Dr. G. V. Jadhav	R. I. Sc.
Moorjani, M. N.	Influence of Heat on the Physico-Chemical Properties of Gum Arabic	Professor C. S. Narwani	D. J. S.
Mulay, L. N.	Part I — Condensation of Phenole and Phenolic Ethers with Acetone Dicarboxylic Acid in the Presence of Condensing Agents other than Sulphuric Acid; Part II—Sulphuryl Chloride, a New Condensing Agent for the Pechmann Reaction—Synthesis of trans 2: 4-Dihydroxy Phenyl Glutaconic Acid	Professor V. M. Dixit	K. C.

Name of the Candidate	Subject of the Thesis	Name of the Professor under whom the Candidate Worked	Name of the Institution
Naegamwala, S. P. (Miss)	A Comparative Study in the Hydrolysis of a Few Edible Oils with Enzyme Lipase and Keeping Power of the Oils	Rao Bahadur Dr. D. L. Sahasrabuddhe	N. W. C.
Pai, M. L.	Enzyme Activity in Cancer with special reference to Butyric-Esterase and Phosphatase	Dr. R. G. Chitre	Tata Memorial Hospital
Pai, M. R.	Adsorption and Surface Tension in Relation to Toxicity	Professor S. V. Bhide	Sir P.
Parikh, B. V.	Studies in Oxidation of Glucose to Gluconic Acid for Calcium Gluconate Preparation by Chemical and Electrolytic Methods	Dr. M. D. Avasare	B. C.
Patel, S. R.	The Behaviour of Solutions of Tilanium Dioxide in Sulphuric Acid in presence of the Sulphates of Metals	Professor S. M. Mehta	R. I. Sc.
Ramkrishnan, C. V.	Synthesis and Hydrolysis of some Aliphatic Esters using Ricinus Lipase from Castor-Seed	Professor N. V. Bhide	N. W. C.
Ranganathan, B.	Normal and Abnormal Mitoses in a Distillary Yeast	Professor M. Sreenivasan	I. I. Sc.
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Sheth, P. G.	Some Attempts to Make out the Mechanism of Chemical Reactions—Thermal Decomposition of (a) Lead Nitrite and (b) Lead Nitrate	Dr. M. S. Shah	G. C.

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Thakkar, R. M.	Bromination of Compounds containing two Aromatic Nuclei	Dr. G. V. Jadhav	I. C.
Thatte, M. M.	A Study of Goat's Milk and Goat's Ghee and its Comparison with that of Cow's Ghee	Rao Bahadur Dr. D. L. Sahasrabuddhe	N. W. C.
Tulpule, P. G.	Study of the Milk and Ghee of Sheep in Comparison with the Milk and Ghee of Buffalo	Professor N. V. Bhide	N.W.C.
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Verghese, G. T.	Physiochemical Investigations on Rubber Latex	Dr. S. K. Bhattacharya	I. I. Sc.
Gupte, R. B.	<i>Geology</i> Part I—A Study of the Geology of the Area Around Gokak; Part II—A Study of the Chemical Composition of Metamorphic Rocks near Ramgad in Konkan, and a Note on the Occurrence of Aragonite in the Secondary Minerals of the Deccan Trap in Miraj State, S. M. C.	Professor K.V. Kelkar	F. C.
Padmanabhan, C. V.	M.Sc. (Tech.) Chemical Finishes on Short Staple Cotton Yarns and Fabrics	Dr. G. M. Nabar	U.D.C.T.
Vyas, G. M.	Hypochlorite Oxidation of Cellulose in Presence of Vat Dyes	Dr. G. M. Nabar	U.D.C.T.
Vyas, H. M.	Studies in Textile Printing : Part I—Preparation of Pigment, printing paste; Part II—Preparation of Rapid Fast Colours	Dr. G. N. Nabar	U.D.C.T.

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	<i>Physics</i>		
Patel, J. M.	Spectral Intensity Measurements in Some Flames	Dr. N. R. Tawde	R.I.Sc.
Paranjpe, M. K.	Further Studies on Thermal Repulsion	Dr. L. A. Ramdas	Met. Office, Poona
	<i>Chemistry</i>		
Gulvady, S. (Miss)	Photochemical Studies in Uranyl Salts both as Photo-active Reagents and Photosensitisers	Dr. S. K. Bhattacharya	I.I. Sc.
Irani, K. R.	Synthetical Anthelmintics-- Synthesis of Substituted Butiro Lactones	Dr. K. S. Nargund	Sir P.
Kanekar, C. R.	Ionic Susceptibilities of Organic Amons and a Study of the Structures of some Compounds	Dr. Mata Prasad	R.I. Sc.
	Ph.D. (Tech.)		
	<i>Textile Chemistry</i>		
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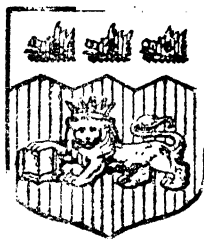
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ON THE CHROMOSOMAL COMPLEX OF TWO SPECIES OF *RICCIA*

BY T. S. MAHABALE¹ AND G. H. GORJI,
Royal Institute of Science, Bombay

INTRODUCTION

THE genus *Riccia* has been a favourite object of study by various authors on account of the important position it holds in the classification of the Marchantiales. Two species of *Riccia* are fairly common at Ahmedabad, which were identified by the late Professor S. R. Kashyap to be *R. himalayensis* St. (now known as *R. discolor* L. et L. under the International Rules of Botanical nomenclature) and *R. sanguinea* Kash. Of these *R. discolor* grows in the monsoons under hedges and on open grounds and *R. sanguinea* on the banks of Sabarmati in the months of December to January. *R. discolor* has been described by Kashyap (1929, p. 93) to be monoecious and *R. sanguinea* as dioecious (Kashyap, *loc. cit.*, p. 96). As both these species were easily accessible locally, it was thought worthwhile to investigate their chromosomal constitution with a view to throwing some light on the monoecism or dioecism of the species in this genus.

The material of both the species was collected in the respective seasons mentioned above and was fixed in Allen's modification of Bouin's fluid, Navaschin's and Carnoy's fixatives. It was dehydrated through the grades of alcohol and imbedded in paraffin after clearing it through a series of xylol grades and cedar-wood oil. Generally the material was transferred to cedar-wood oil from absolute alcohol in the evening and was left over-night. This softened it considerably in addition to clearing. The sections were cut 8-12 μ thick and were stained with Haidenhain's iron-haematoxylin or Gentian violet, using saturated aqueous picric acid solution as the destaining agent. This procedure is different from the one given by Chamberlain (1932), but gives very good results.

The chromosomes in young antheridia were easily studied by this method; but the attempts to study them in meiosis or meiotic mitosis were not successful due to the presence of chlorophyll and plastic food material present in the sporocytes. The presence of these bodies made the changes in nuclear cycle in meiosis difficult to follow. Greater attention, therefore, was paid to the study of the spermatogenous mitoses on which the following description is based.

DESCRIPTION

Figs. 1 and 2 show the chromosomes at different stages in the developing antheridia in early spermatogenous mitosis. Many such cells, either at the diakinesis or lying on the spindle, as shown in Fig. 1-d, or at metaphase (Fig. 1-b and c), were noticed in the segments of the antheridia. Fig. 1 shows them in *R. discolor* and Fig. 2 in *R. sanguinea*. As

a matter of fact, all the cells of a segment of an antheridium generally show the same stage of mitosis such as metaphase at a time. It is quite obvious from these Figs. that the chromosomal complex of *R. discolor* consists of 8 chromosomes (n-number) with two pairs of long slender, more or less 'V'-shaped chromosomes. A third pair of chromosomes slightly bent in form is smaller in structure than the 'V's mentioned above. Out of the remaining two chromosomes one is slender and bent unevenly and the other is small and dot-shaped. The attachment in the case of 'V's is atelomitic and in the case of others telomitic. The number of chromosomes, 8, was also verifiable at early diakinesis.

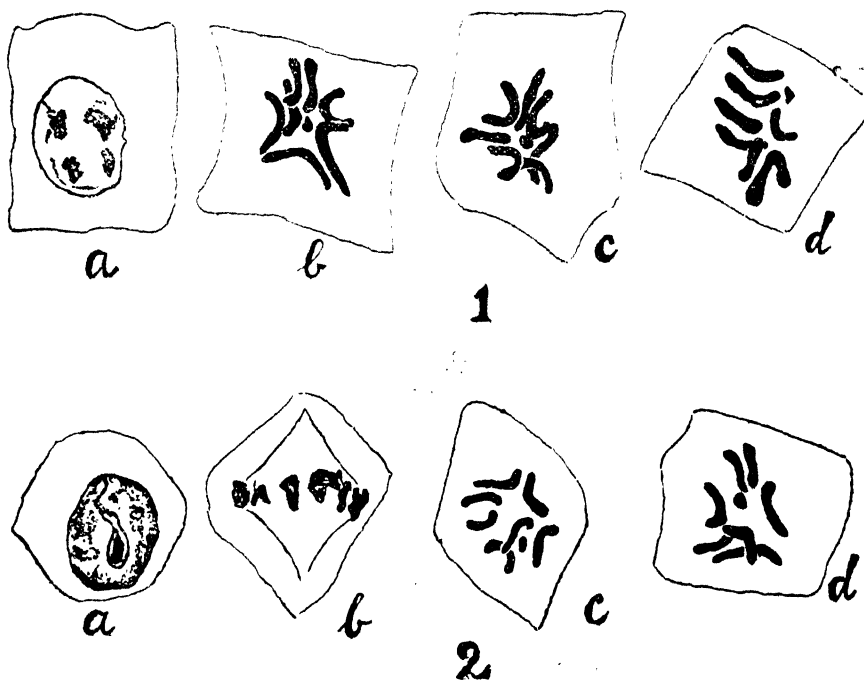


FIG. 1. *Riccia discolor* L. et. L.

Chromosomes during the spermatogenous mitoses $\times 1500$. a—diakinesis; b and c—metaphase plates (lateral view) showing 8 chromosomes; d—*ibid.*, slightly oblique view.

FIG. 2. *Riccia sanguinea* Kash.

Stages in the spermatogenous mitosis showing 8 chromosomes $\times 1500$. a—nucleus in the prophase; b—spindle in the lateral view; c and d—two metaphase plates showing 8 chromosomes.

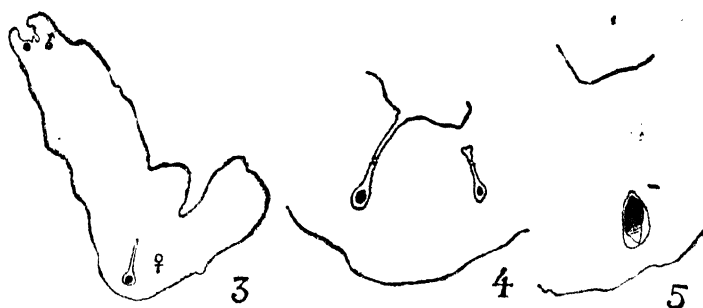
The chromosomal complex of *R. sanguinea*, which had not been so far described, is shown in Fig. 2. In Fig. 2-a the nucleus is in prophase and shows a precociously staining chromosome. Fig. 2-b shows the lateral view of the spindle and Figs. 2-c and d show the polar view of the metaphase plates. It will be noticed, that here also there are 8 chromosomes, more or less similar to those of *R. discolor* described above, the only difference being their slender nature and smaller size. The pairs of 'V'-shaped chromosomes lie peripherally, as do the rest of the chromosomes except the dot-shaped chromosome which lies

centrally. In point of the chromosomal constitution, therefore, there is very little difference between the two species despite the fact that one is described as dioecious and the other monoecious. It is also evident that the basic number of chromosomes is 8 in the genus *Riccia* as stated by Mahabalé (1942, p. 144).

This raises a very important question *viz.*, what is the mechanism of sex in the genus *Riccia*: Schrader (1928), Lorbeer (1927) and others are inclined to correlate this difference with the odd unpaired chromosome and the dot-shaped element in the chromosomal constitution of the genus and there is some evidence to support this view. According to White (1946), Schrader (1928) and others the sex chromosomes are distinguished from the autosomes by the following three characteristics:—

- (i) precocious appearance in prophase,
- (ii) precession on the metaphase spindle, and
- (iii) heteromorphism.

It has been shown by Lorbeer (1927) and Srinivasan (1940, p. 73, also in Fig. 64) that the small dot-shaped chromosome of *R. discolor* shows precession on the spindle at the anaphase. Its form also is not the same as that of the rest. It, therefore, possibly represents the sex chromosome. But such a conclusion, regarding the chromosomal constitution of the whole genus *Riccia* based on a species or two will be hazardous, in view of the fact that McAllister (1928) did not find any such behaviour of the small chromosome in *Riccia curtisii*. Nor was precession noticed in *R. sanguinea* in the present investigation. It is likely, therefore, that the segregation of the sex chromosome may be taking place at the time of reduction division, the constitution of the gametophyte being largely determined by the nutritional conditions. In other words, the sex may be mainly metabolic in *Riccia*, and dioecism or monoecism may not necessarily mean the presence of sex chromosomes. It is on this point that some further evidence may be adduced here, notwithstanding the presence of the dot-shaped chromosome noticeable in the centre of the metaphase plate in both the species investigated.



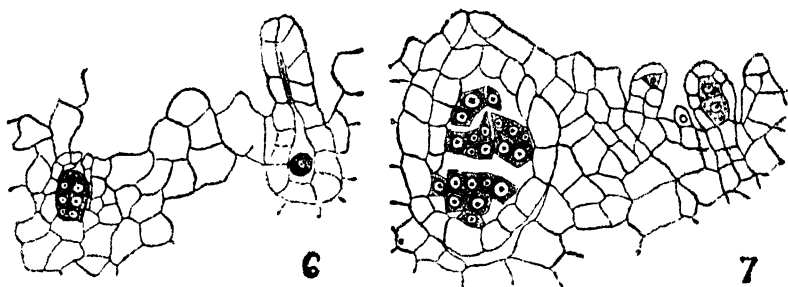
FIGS. 3-5. *Riccia sanguinea* Kash. showing the monoecious nature of the thallus $\times 10$.

FIG. 3. Surface view of a thallus showing an theridium near the apex and an archegonium in the median groove.

FIG. 4. Thallus showing two archegonia.

FIG. 5. V. S. of the same thallus showing an antheridium.

Kashvap (1929), who first described *R. sanguinea*, found the plants to be dioecious. Pande (1924) who studied the life-history of this species also found that it is dioecious like *R. michelii* and *R. frostii*. His figures and the account bear out the point clearly. When a large number of thalli of this species were cut and microscopically examined a few thalli showing hermaphrodite characters were discovered. They had archegonia on the older parts of the thallus in the grooves and antheridia near the growing point. As a rule, however, it was difficult to obtain both the archegonia and the antheridia in one and the same section of the thallus, as the growing point near which the antheridia are found lies on an inclined plane, and the archegonia lie behind it in the depression of the median groove. Figs. 3-7 are transverse sections of such thalli of *R. sanguinea*. In Fig. 3 an antheridium is visible near the growing point of the thallus, behind which at a distance lies an archegonium. In Figs. 6 and 7 also a young developing antheridium and an archegonium are being seen on the same thallus. Figs. 4 and 5 are the 7th and the 11th sections of a series of sections of another thallus cut vertically. In section 7 of this series (Fig. 4) there are two archegonia and in section 11 (Fig. 5) in the same series there is an antheridium, the sections having been cut 12 μ apart.



FIGS. 6 and 7. *Riccia sanguinea* Kash. $\times 200$.

FIG. 6. V. S. of a thallus showing young antheridium and an archegonium.

FIG. 7. V. S. of a thallus showing an antheridium and young developing archegonia.

It is obvious from these that *R. sanguinea* though generally considered to be dioecious having two kinds of thalli, large green bearing archegonia and small red bearing antheridia, the former may give rise the antheridia occasionally. In spite of a careful search, the reverse condition, viz., the thallus predominantly male forming many antheridia was not found to produce archegonia afterwards. This suggests that there is a predisposition towards a particular sex in *Riccia*, as in the prothalli of *Equisetum debile* (vide, Mahabale, 1946, pp. 45-46). It is well known from the work of Perkin (1908), Czaja (1921) and others on the fern prothalli, that monoecism or dioecism is largely a condition attendant on the nutrition, although the spores have such a tendency. The monoecism or dioecism, therefore, is also dependent on the causes other than chromosomes and, therefore, it cannot be regarded as a stable character that could be relied on for the purposes of taxonomy. It rather suggests that sex is more a condition than a character. But

whether this means that the dot-shaped chromosome is really a chromosome to be identified with the sex chromosome, must be left an open question till the chromosomal complex at meiosis during the sporogenesis has been fully worked out. Attempts in this direction are being made by the authors. It will be better till then to reserve our judgment on the mechanism of sex in the genus *Riccia* as a whole. One thing which seems certain at this stage of investigation is that the monoecious or dioecious nature of the thallus does not in itself afford a very reliable character for the purposes of taxonomy of the genus. *R. sanguinea* is not necessarily dioecious and may show all intergradations of sexuality which is rather a condition than a character. This has also been found to be true with regard to some of the European species such as *R. natans* and *R. frostii* which were formerly considered to be strictly dioecious by Leitgeb (1879), Schiffner (1893) and Campbell (1918) and have been found to be monoecious by later workers like Garber (1904) and Lewis (1906).

SUMMARY

The chromosomal complex of *Riccia discolor* L. et L. (= *R. himalayensis* St.) and *Riccia sanguinea* Kash. consists of 8 slender chromosomes (n-number) 7 of which are more or less V-shaped or bent and one is small and dot-shaped lying in the midst of the remaining seven. Whether this dot-shaped chromosome is to be identified with the sex chromosome can only be decided after the meiotic cycle of the chromosomes has been fully worked out. There is not much difference in the genomic constitution of the two species although *R. discolor* has been described as monoecious and *R. sanguinea* to be dioecious. A critical examination of a large number of thalli of *R. sanguinea* revealed that some of the thalli bearing archegonia, also formed a few antheridia, which possibly suggest that sex is more a condition than a character in the genus. At any rate the monoecious or dioecious nature of the thallus, not being a stable character, is not suitable for the purposes of taxonomy of the genus.

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CONTRIBUTIONS TO THE EMBRYOLOGY OF THE ANONACEAE

I. *Artabotrys odoratissimus*, R. Br.¹

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I. INTRODUCTION

THE family Anonaceae is claimed to be the nearest ally of Magnoliaceae, generally considered to be a primitive family in the Angiosperms; and yet only a few investigations have been made on it. The importance of the Anonaceae, apart from its relationship with the Magnoliaceae, lies in its being one of the foremost families possessing monocotyledonous characters, as stated by Fries (1911), Weisse (1925), Wettstein (1935) and others.

The chief features in the embryology and cytology of the Anonaceae have been ably summarised by Schürhoff (1926) and Schnarf (1931). Juliano (1935) has given an account of the development of the flower, megasporange and gametophyte in *Anona muricata* and *A. squamosa*. Microsporogenesis and cytokinesis in *Asimina triloba* have been described by Locke (1936). Kumar and Randive (1941) have studied the cytology of the genus *Anona*.

A critical study of the literature suggested the desirability of investigating the family again and attempts in this direction were made by one of us (R. D. A.)² since 1937. The present paper gives an account of the investigations made on *Artabotrys odoratissimus*, R. Br. as no observations on this genus have been previously recorded.

II. MATERIAL AND METHODS

Artabotrys odoratissimus, probably a native of South India, is largely cultivated in other parts for its fragrant flowers.

Several fixing fluids were used. The best results were obtained with Karpenchanko's modification of Navashin's fluid with a prefixation in Carnoy's acetic—alcohol—chloroform solution for 10-20 seconds (La Cour, 1931). A suction pump was used to ensure rapid penetration but it was found rather harmful with materials prefixed with Carnoy's

¹ A part of the thesis submitted for the Ph. D. Degree in Botany to the University of Bombay, 1944.

² "Floral organogeny and the structure and development of the micro- and megaspores and their gametophytes in *Anona squamosa* L. and *A. reticulata* L.", a thesis submitted for the M.Sc. degree to the University of Bombay, 1937.

solution. After fixation, the material was washed, dehydrated, cleared and imbedded in the usual manner. In some preparations thin cedar wood oil was used as a clearing agent, as recommended by Digby (1919), Rau (1929) and others.

Depending on the stage of development sections were cut 8-20 μ thick. The most satisfactory staining was obtained with the Haidenhain's iron—alum haematoxylin. Liquor ferri was used successfully as a mordant, thus avoiding the use of ammonium sulphate of iron which does not usually keep long without forming precipitates. Liquor ferri was prepared in the laboratory by the method given by Rau (1935). Yamanouchi's schedule (Chamberlain, 1932) was followed for the staining process, but staining for 20-30 minutes was found to be quite sufficient. The same Liquor ferri fluid, diluted to 1% with distilled water, was used for destaining.

III. DESCRIPTION

A. MICROSPORANGIUM

(a) *Archeporium*.—An anther is merely a mass of homogenous cells in its early stages, more or less circular in outline, but soon becomes faintly two-lobed. A group of deep staining archesporial cells makes its appearance in each one of these lobes (fig. 1).

The central cells of each archesporial group get sterilized and form four patches of archesporium out of the original two (fig. 2). Simultaneously little constrictions appear in each of the two anther-lobes and the anther becomes four-lobed.

(b) *Primary Parietal and Sporogeneous Cells*.—The cells in each of the four groups divide further. The cells of the outermost layer of each archesporial mass elongate radially (fig. 3) and divide periclinally, forming primary parietal or wall cells and the primary sporogenous cells. The remaining archesporial cells may divide once or twice, but do not form the sporogenous cells and hence may be called the 'sterile archesporial cells' (A in fig. 3).

(c) *Parietal Cells*.—The primary parietal and the primary sporogenous cells now divide periclinally and anticlinally. In the figure 4, four such parietal layers are formed, out of which the innermost has begun to differentiate as the outer tapetum.

In the Figure 5 the anther wall consists of 5-6 layers, out of which the subepidermal layer forms the endothecium, with elongated cells. In between the endothecium and the outer tapetal layer, 2-3 parietal layers constitute the 'middle layers' (fig. 5). The parietal cells may divide further, finally forming 5-6 parietal layers, a characteristic of this plant (fig. 6).

(d) *Sporogenous Cells*.—The primary sporogenous cells divide, forming 2-4 layers. These cells are much larger than the tapetal cells, and form the pollen mother cells.

(e) *Endothecium*.—As the pollen mother cells undergo two meiotic mitoses and the pollen grains get matured, some important changes take place in the adjoining tissues. The endothelial cells continue to elongate (figs. 6, 7), and bands of thickening appear on three sides, the inner and radial sides. The thickenings become very conspicuous when the pollen grains are binucleate and the anthers are about to dehisce. The endothelial cells, however, do not develop any transverse striations or fibrous thickenings. The epidermis of the anther becomes flattened and finally disorganised, leaving an irregular residue on the endothelial cells (fig. 7). A few endothelial cells, in the middle of each of the anther-lobes, do not get thickened. These thin cells break down and open the loculus of the anther.

* (f) *Middle Layers*.—The cells of the middle layers remain undifferentiated till they get disorganised due to the enlargement of the tapetum and the endothelial cells. The disorganisation starts with the innermost middle layer i.e. the layer adjacent to the outer tapetum. This may take place early when the reduction division has just started in the pollen mother cells. In a fully matured anther all these middle layers are completely disorganised.

(g) *Sterile Archesporial Cells*.—The outermost layer of the sterile archesporial cells forms the inner tapetal layer. The rest of the sterile archesporial cells, lying in 2-4 layers, do not get differentiated, and disorganise almost simultaneously with the middle layers noted above.

(h) *Tapetum*.—The tapetum on the outer side is developed from the innermost parietal layer, while on the inner side it develops from the outermost layer of the sterile archesporial cells. The tapetum is not, therefore, sporogenous in origin.

The tapetum is differentiated from the adjoining middle cells or the sterile archesporial cells by their large size and dense contents (figs. 4-6). In younger stages, the tapetal cells are uninucleate with one or more vacuoles (fig. 8). The position of these vacuoles is not definite, sometimes near the walls next to the pollen mother cells or sometimes near the opposite walls.

By the time the nuclei of the pollen mother cells are in the early prophase of the meiotic mitosis, the tapetal cells become binucleate by ordinary mitotic divisions (figs. 9, 10, 11). No amitotic divisions were noticed.

As the tapetal cells become binucleate, the cytoplasm increases and the vacuoles, invariably observed in the uninucleate tapetal cells and also present in the early binucleate condition, disappear (fig. 11).

The two nuclei of the tapetal cells, when newly formed, show one or two large nucleoli and a few small dark bodies. But soon after this stage the number of dark bodies increases, 1-4 of which are larger than the rest (fig. 11). More than two nuclei were not noticed in the tapetal cells, as the two nuclei do not undergo any further divisions,

The tapetal cells begin to disorganise after the two meiotic mitoses are completed and young microspores have separated from the old mother cell wall. The tapetal cells become prominently vacuolate, the cell walls become indistinct and the cytoplasm from different cells gets mixed together (fig. 7). No periplasmodium has been observed in this plant. However, in a few cases (fig. 12), the tapetal cells were found to project a little between the pollen grains, possibly indicating a tendency towards the formation of a periplasmodium.

Later on the tapetal mass decreases and by the time the pollen grains are fully matured and anthers start dehiscing, it completely disappears.

B. MICROSPOROGENESIS, POLLEN GRAIN AND THE MALE GAMETOPHYTE

The details of microsporogenesis will be dealt with elsewhere, the n-number of chromosomes observed being 8 as previously recorded (see Asana and Adatia, 1945).

(a) *Young Pollen Grain*.—When the microspores are liberated from the tetrads, they are more or less angular in outline, but very soon they assume a spherical form. A conspicuous nucleus lies in the centre of the grain and may contain one or more nucleoli. The development of the exine and the intine follows the normal course.

Usually all the pollen grains are completely separated from one another at a very young stage. Only in one case, two large mature pollen grains were seen adhering together.

(b) *Ripe Pollen Grain and Male Gametophyte*.—As the pollen grain is maturing, the vacuoles in the cytoplasm become larger (fig. 13) till the cytoplasm is found mainly round the nucleus and at the periphery of the cell. The nucleus migrates to one corner and undergoes division (fig. 14). The two daughter nuclei formed are unequal in size. The larger nucleus, the vegetative nucleus, and the smaller nucleus, the generative nucleus, are both spherical in form and are found to retain this shape in the later stages also. No crescentic form was noticed. Each of these nuclei contains 1-4 nucleoli.

Soon the generative nucleus gets itself surrounded by a mass of cytoplasm and a generative cell is organised at the corner of the pollen grain (fig. 15). The generative cell gets separated from the rest of the cytoplasm in the pollen grain by a distinct curved space around it. Even after careful observations no definite cell wall was seen. Locke (1936), however, describes that in *Asimina triloba* the generative nucleus surrounded with a small amount of cytoplasm is set off from the tube cell by a membrane. Such a membrane was not observed in the present study.

This concave space soon vanishes (fig. 16). The cytoplasm of the generative cell, however, is recognizable from that of the vegetative cell for some time (fig. 16). But soon it mixes with the latter and then the generative nucleus alone, but not the generative cell, is distinguishable.

The generative nucleus leaves its peripheral position and penetrates the vegetative plasm. It lies free in the cytoplasm of the pollen grain. Here it increases in size and attains almost the same size as that of the vegetative nucleus (figs. 17, 19). The staining capacity of both of these nuclei was found to be the same in all the preparations stained with hæmatoxylin.

As these changes are taking place the cytoplasm of the pollen grain increases in quantity and finally becomes alveolar in appearance and food materials get deposited in it.

The generative nucleus was not observed to divide to form two male nuclei, the pollen being shed at the two-nucleate stage. In two cases, however, three small nuclei were seen inside the mature pollen grain (fig. 18). But it was not possible to trace the actual origin of the third nucleus. All the three nuclei were of the same size and had the same staining capacity. They were much smaller than the ordinary vegetative or the generative nucleus.

The mature pollen grains are about 45μ in diameter. However, pollen grains of different sizes are occasionally produced by the same flower. In such flowers some of the pollen grains are of the normal size, while the others are as large as 90μ in diameter (fig. 19). These large or 'giant' pollen grains have very large vacuoles. Wherever these giant pollen grains occurred, they were found in the mass filling up the entire loculi of the anthers. No smaller pollen grains were generally observed to occupy the same loculus of the anther.

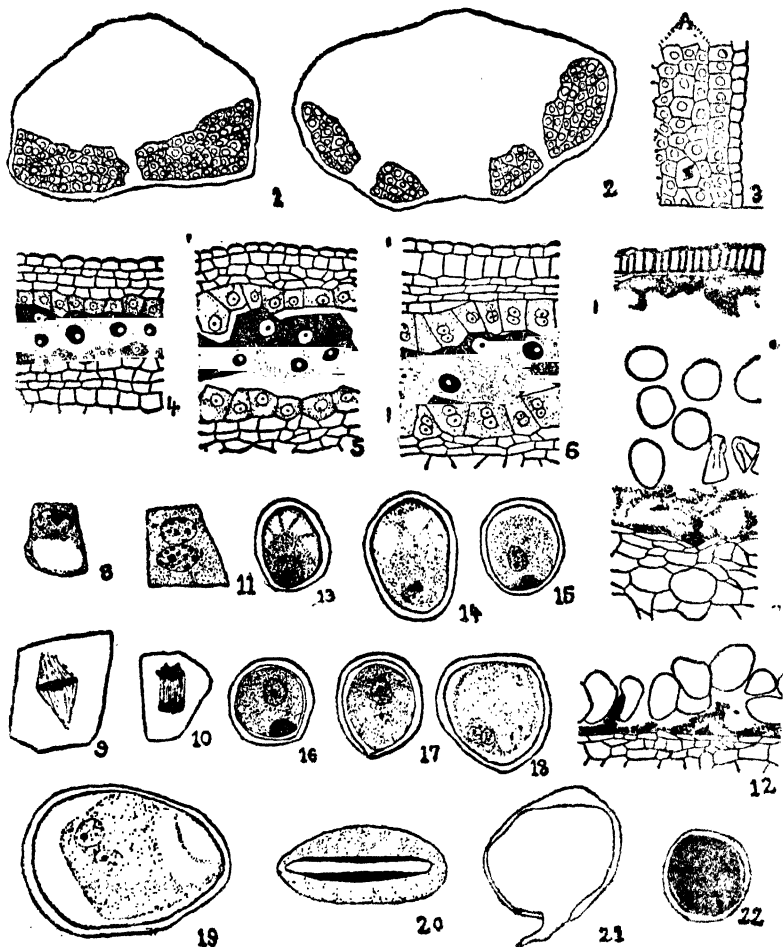
In the ripe pollen grain the exine is much thicker than the intine, the former being distinctly granular. The pollen grain does not develop, however, any spines or ridges on their outer surface, and it can be described to be of "psilate" nature, according to the terminology of Wodehouse (1935).

The pollen grains, when observed by the aniline oil gentian violet method, were found elongated with tapering ends (fig. 20), looking boat-shaped and not rounded. Another important feature, which was noticed by this method, was the presence of a single narrow longitudinal furrow, extending almost from one end to the other, making the pollen grains monocolpate.

(c) *Pollen grains germinating 'in situ.'*—Some pollen grains were found to give out small protuberances (fig. 21) when they were still inside the undehiscent anther. These pollen tubes, however, were very small and their contents could not be identified due to the dark contents.

(d) *Degeneration of the pollen grains.*—Frequent cases of degeneration were observed in this plant (fig. 22). In a few cases the entire loculus and sometimes all the four pollen sacs of the anther showed degenerated pollen grains.

Examination of pollen grains with lactic acid also revealed the presence of numerous defective pollen grains.



FIGS. 1—22. *Artabotrys odoratissimus*, R. Br.

Figs. 1—2—T. S. of young anthers showing groups of archesporial cells. $\times 155$. Fig. 3—Part of L.S. of anther, showing the radial elongation of the cells of in the outermost layer of the archesporial mass. A—sterile arstesporial cells. $\times 250$. Figs. 4—6—Same, older stages. $\times 250$. Fig. 7—Same, older stage, disorganised tapetum. $\times 155$. Fig. 8—Uninucleate tapetal cell. $\times 600$ (approx.). Figs. 9—10—Mitotic divisions in the tapetal nuclei $\times 600$ (approx.). Fig. 11—Binucleate tapetal cell $\times 600$ (approx.). Fig. 12—Part of L. S. of anther showing irregular projections of the disorganised tapetal mass in between the pollen grains. $\times 155$. Fig. 13—Uninucleate pollen grain. $\times 250$ (approx.). Fig. 14—Pollen grain with dividing nucleus. $\times 250$ (approx.). Figs. 15—16—Pollen grain, showing the generative cell. $\times 250$ (approx.). Fig. 17—Mature pollen grain. $\times 250$ (approx.). Fig. 18—Pollen grain with three nuclei. $\times 250$ (approx.). Fig. 19—Giant pollen grain. $\times 250$ (approx.). Fig. 20—Pollen grain showing furrow by aniline oil gentian violet method. $\times 250$ (approx.). Fig. 21—Germinating pollen grain *in situ*. $\times 250$ (approx.). Fig. 22—Degenerated pollen grain. $\times 250$ (approx.).

C. MEGASPORANGIUM

(a) *Archesporium and the megasporocyte*.—The nucellus, consisting of similar cells, is straight but becomes curved afterwards. The inner integument primordium appears and a single cell, in the fourth layer

of the nucellus, becomes larger and stains deeply (fig. 23). Rarely a large cell was noticed in the first or second hypodermal layers (figs. 25, 26). These cases suggest that the primary archesporial cell may have originated in the first hypodermal layer, but it was indistinguishable. In such abnormal cases (figs. 25, 26) the parietal cell formation is only delayed or the parietal cell fails to complete its division rapidly. The large cell in the fourth nucellar layer never divides periclinally and is the megaspore mother cell, and not the primary archesporial cell.

(b) *Nucellus*.—Due to the divisions in the parietal cells the megaspore mother cell lies deeply in the nucellus. The epidermis does not contribute to the formation of any parietal layer. When the nucleus of the megaspore mother cell enters the prophase of the meiotic mitosis, the latter usually lies in the fourth or the fifth layer of the nucellus (fig. 27); when the spindle appears in this cell, it lies in the seventh or the eighth layer (fig. 29).

The maximum number of parietal layers is 8—9 and this is attained when the embryo sac organisation has just started in the chalazal megaspore (fig. 34). All these parietal layers, however, do not persist in the later stages. The nucellus shows about 4—6 layers of cells at the side of the embryo sac, and about 20—21 layers of cells below the embryo sac.

A bluish black mass was observed in the nucellus at the chalazal tubular end of the embryo sac first at the bi-nucleate stage; it became very conspicuous at the eight-nucleate stage (figs. 40, 41) and persisted even after fertilization. The cells in the bluish black mass, as well as in the adjoining colourless mass of the nucellus, were arranged in regular radiating rows (fig. 42).

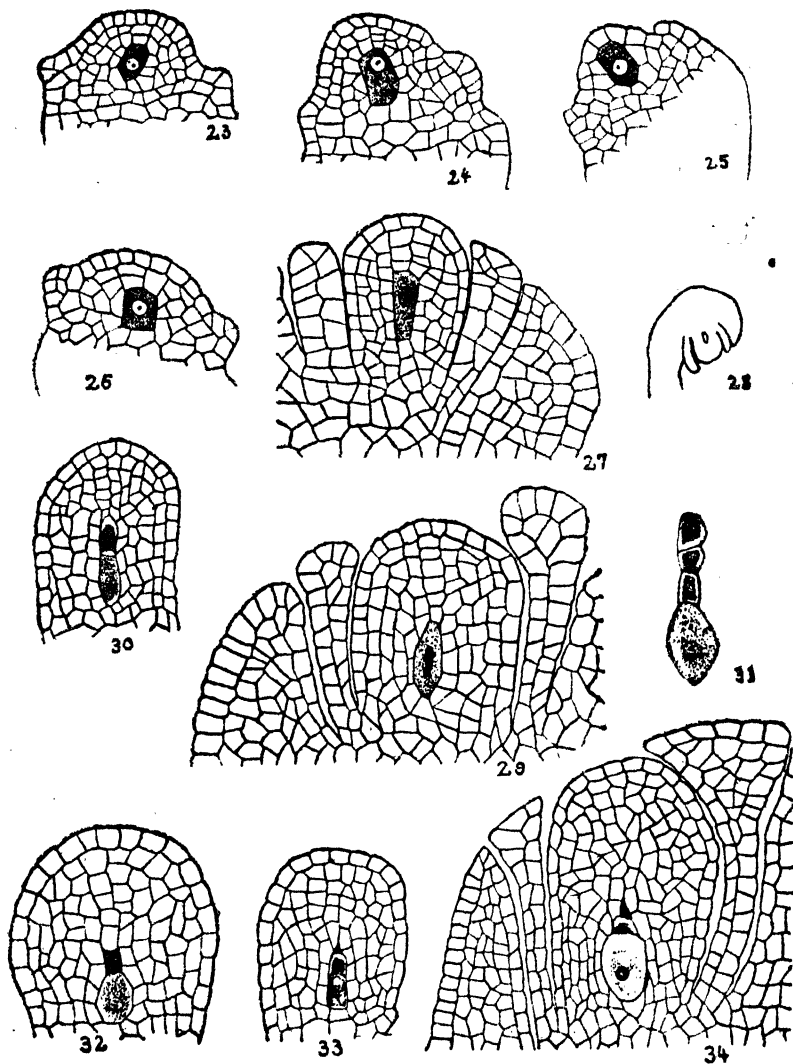
The ripe ovule is anatropous. When the nucleus of the megasporocyte shows the meiotic spindle, the ovule curves more than 90° (fig. 28) and becomes quite anatropous when the embryo sac is binucleate (fig. 37).

(c) *Integuments*.—The ovule is two-integumented. The integuments arise exogenously, only the epidermis taking part in their formation (figs. 25, 26). The inner integument originates with the archesporium (fig. 25). It reaches the level of the nucellus and over-arching forms the micropyle. It always remains only two cells thick upto the level of the nucellus apex; but in the micropylar region, adding more layers, it becomes 10—11 layers thick in the mature ovule (fig. 40).

The outer integument follows the inner integument, arising as a small protuberance when the megasporocyte is in the fourth or the fifth nucellar layer (fig. 24). The two integuments then continue to grow as two rims all around the nucellus. The outer integument never attains the same height as the inner integument, reaching only the lower portion of the micropyle. It becomes 7-9 cells thick in the mature condition (fig. 40). Unlike the inner integument it becomes slightly thin as it goes towards the micropyle. Both the integuments and the nucellus are free from one another right upto the base.

The cells of the outermost layer of the outer integument elongate anticlinally early (figs. 27, 29) and remain as such in the mature ovule. After fertilization, these cells as well as the cells of the inner integument are filled with a dark stained material.

(d) *Size of the ovule.*—The mature ovule measures about 480μ in length and 270μ in breadth.



FIGS. 23—34. *Artabotrys odoratissimus*, R. Br.

Figs. 23-24—L. S. young ovules showing megaspore mother cell in the fourth nucellar layer. $\times 250$. Fig. 25—L. S. young ovule showing the primary archesporial cell in the first hypodermal layer. $\times 250$. Fig. 26—Same, megaspore mother cell in the third nucellar layer. $\times 250$. Fig. 27—L. S. ovule, the megasporocyte nucleus, early meiotic prophase. $\times 250$. Fig. 28—L. S. ovule, showing the first spindle in the megasporocyte nucleus. $\times 41$. Fig. 29—Part of the same, magnified. $\times 250$. Fig. 30—Dyad stage, L. S. $\times 250$. Fig. 31—Tetrad of megaspores. $\times 250$. Fig. 32—Part of L. S. ovule showing a mass of degenerated megaspores at the micropylar end of the large functioning chalazal megaspore. $\times 250$. Fig. 33—Part of L. S. ovule, the third and fourth megaspores enlarging simultaneously. $\times 250$. Fig. 34—Functioning chalazal megaspore organising embryo-sac. $\times 250$.

D. MEGASPOROGENESIS, EMBRYO SAC CELL AND FEMALE
GAMETOPHYTE

(a) *Megasporogenesis*.—The megaspore mother cell begins to enlarge and its nucleus shifts to the micropylar end. It undergoes two meiotic divisions in the normal manner. The first division is initiated when the megaspore mother cell is in the fourth or the fifth nucellar layer (fig. 27). In the early prophase nucleolar budding as well as 3—4 small extra nucleoli are sometimes observed. After the completion of the first meiotic division, the two dyads are separated by a distinct wall (fig. 30), often the micropylar dyad being smaller than the chalazal one. After the second division in both of the dyads a regular row of four megaspores is formed (fig. 31).

(b) *Development of the embryo sac*.—Immediately after the formation of the tetrad, usually the chalazal spore begins to enlarge (fig. 31). The selection of the megaspore is of the fixed type. The degeneration of the upper sterile sister cell takes place quickly, beginning with the micropylar megaspore. The degenerated megaspores appear as crescents or as irregular masses over the functional megaspore. As the chalazal megaspore enlarges, they form a deeply stained mass at the micropylar end (fig. 32).

Sometimes both the third and the fourth megaspores from the micropylar end enlarge simultaneously, though the fourth still predominates (fig. 33). The nucleus of the third also sometimes enters the prophase of the meiosis, but no further stages were observed.

The functioning megaspore or the primary embryo sac cell organises the embryo sac. The cytoplasm becomes vacuolated. Two vacuoles appear at the two ends (fig. 34). The functioning megaspore has now changed to a uninucleated embryo sac. As it enlarges it encroaches upon the mass of the degenerated sister spores and the adjoining nucellar cells which get crushed and stain deeply with hæmatoxylin.

The central nucleus of the embryo sac enters the first mitotic division and forms two nuclei, the primary micropylar and the primary chalazal (fig. 35). The two nuclei move apart, one to the micropylar and the other to the chalazal end (fig. 36). The degenerated megaspores completely vanish and merge into the surrounding tissue. With the further increase in size of the embryo sac the two polar vacuoles get replaced by a large central one (fig. 36).

The two nuclei, at the ends of the embryo sac cell, divide, the spindles being parallel or at different planes. The tetra-nucleate stage (fig. 38) was frequently met with in the slides. Possibly it extends over a large period. A median constriction, sometimes seen at this stage in the embryo sac (fig. 38), is usually lost during further development.

By further division of the four nuclei an octo-nucleate megagametophyte, typical of angiosperms, is formed. As very few sections showed this stage, it appears that it is gone through rapidly.

(c) *Organisation of the mature embryo sac.*—The mature embryo sac is usually broad near the micropylar end, about $50-60\mu$ in diameter. It tapers at both ends, the length being $150-160\mu$.

The two quartets of nuclei organise themselves into an egg apparatus at the micropylar end, antipodals at the chalazal end, and two polar nuclei in the middle (fig. 41). The cytoplasm remains dense only in the neighbourhood of the egg apparatus, polar nuclei and the antipodals. In later stages starch was seen in the embryo sac.

Egg apparatus.—The egg apparatus, when fully organised, measures about 35μ in length. The synergids (figs. 43 and 44) are usually pyriform, sometimes irregular. No well developed beaks at their apices facing the micropyle were seen. The synergids are not hooked and show no "filiform apparatus" of Schacht with minute striations. They have large basal vacuoles. The nucleus lies in the midst of dense cytoplasm which fills up the micropylar half.

The egg cell is pyriform or irregular (fig. 44). In the young stages it is placed between the two synergids (fig. 41) and is masked by them, but later it becomes larger than the synergids, its broad base extending beyond them into the gametophyte. It has a prominent vacuole in the micropylar end, the nucleus occupying the opposite end. The egg nucleus, with one or two nucleoli, is distinctly larger than the synergid nucleus.

The synergids are short-lived, degenerating in many cases even before the pollen grains were received by the stigma.

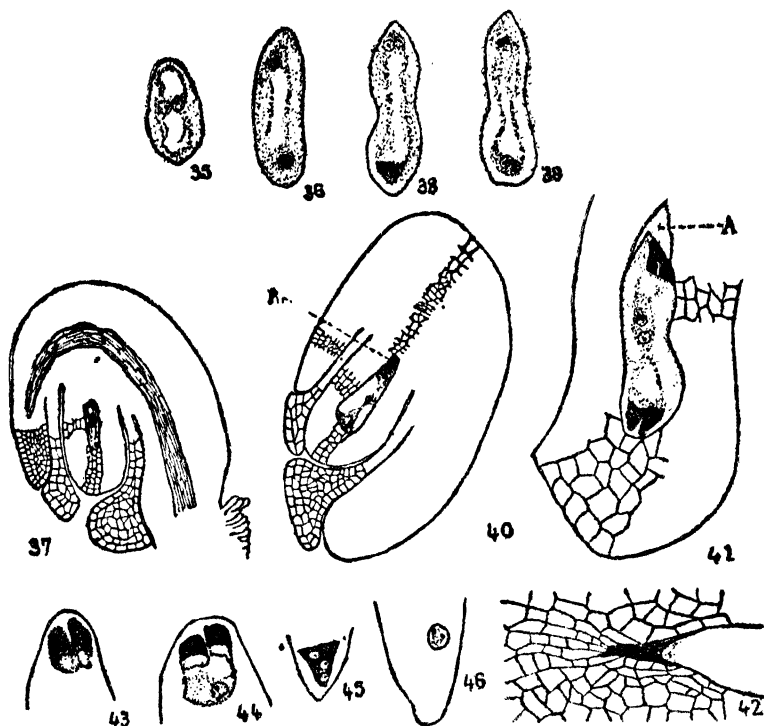
Antipodals.—Three small antipodals, full of cytoplasm and separated from one another by distinct cell walls, are a usual feature of this plant (fig. 41). Their position in relation to one another is variable (figs. 41, 45).

No increase in the size and number of these cells and their nuclei was noticed after their organisation. The cells usually degenerate before fertilization.

Secondary nucleus.—The polar nucleus at the micropylar end of the embryo sac and the egg nucleus were seen close to each other in some sections; presumably they are sister nuclei. Both the polar nuclei increase in size as they move to meet each other in the middle of the embryo sac (fig. 41). When they touch each other they appear largest of all the nuclei in the embryo sac. The two nuclei remain closely pressed against each other for a long time, fusing rather late, before fertilization. Fig. 46 shows a secondary nucleus with two nucleoli, indicating only a partial fusion at this stage.

The secondary nucleus, or the two polar nuclei, closely adpressed together, were not observed to remain at any fixed place in the embryo sac.

(d) *Degenerations.*—Several cases of degeneration at the four-nucleate or the later stages of the embryo sac were noticed (fig. 39). It is interesting to note in this connection that in this plant two ovules always occur in the loculus of a carpel before fertilization. After fertilization two young seeds may be observed, but later only one comes to maturity.



FIGS. 35-46. *Artabotrys odoratissimus*, R. Br.

FIGS. 35-36—Binucleate embryo sac. $\times 250$. FIG. 37—L. S. ovule with a binucleate embryo sac. $\times 80$ (approx.). FIGS. 38-39—Four-nucleate embryo sac. $\times 250$. FIG. 40—Mature embryo sac. (L. S.). A—bluish black mass $\times 80$ (approx.). FIG. 41—Octo-nucleate embryo sac. A—bluish black mass. $\times 250$. FIG. 42—L. S. of the chalazal end of ovule showing a bluish black mass and the regular radiating rows of cells around it. $\times 120$ (approx.). FIG. 43—Synergids. $\times 250$. FIG. 44—Egg apparatus. $\times 250$. FIG. 45—Antipodals. $\times 500$. FIG. 46—Secondary nucleus showing two nucleoli. $\times 250$.

IV. DISCUSSION

(a) *Archivesporium in the microsporangium*.—Unlike the other flowering plants, the archivesporium in *Artabotrys odoratissimus* appears as two groups of cells and four groups are formed by sterilization.

Archivesporial cells in groups have been reported in *Lemna minor* (Caldwell, 1899), *Najas*, *Zannichellia*, *Elodea canadensis*, *Ruppia maritima*, *Monochoria vaginalis*, *Hydrilla verticillata*³, *Limnophyton obtusifolium* (Johri, 1935a), *Sagittaria sagittifolia* (Johri, 1935b), *S. guayanensis* (Johri, 1935d), *Alisma plantago-aquatica* (Johri, 1936a), *Aponogeton monostachyon* and *A. crispus* (Sane, 1939). A similar origin in *Artabotrys odoratissimus* lends a support to the affinity of this family with Monocotyledons, as most of the plants reported in this connection are Monocotyledons.

An essentially parallel condition as found in the present plant is reported by Singh (1936) in *Ranunculus sceleratus*, belonging to the allied family Ranunculaceae.

As cited by Johri (1935a).

(b) *Tapetum*.—The tapetum is not sporogenous in origin in the present plant. It is reported to be sporogenous in Ranunculaceæ (Coulter, 1898), Magnoliaceæ (Maneval, 1914) and Polycarpicæ (Schnarf, 1931); but in recent years several authors have shown a parietal origin of the tapetum even in those cases where the sporogenous origin was previously reported (Singh, 1936, Johri, 1935a, 1935b, 1935d, 1936a, 1936b and Sane, 1939). The authors, therefore, feel that these observations require reconfirmation.

The tapetal cells of *Artabotrys* are binucleate. Cooper (1933) groups the plants in the three classes according to the nature of the tapetal cells. *Artabotrys* fits into the second class, where nuclear divisions in the tapetum take place only once resulting in the mature binucleate tapetal cells.

Artabotrys odoratissimus shows only a tendency towards the formation of periplasmodium, which has been observed in *Anona squamosa* (Juliano, 1935), *A. reticulata*, *A. muricata*, *A. cherimolia*, *Polyalthia*, *Unona* and *cananga*.⁴

Some systematic importance has been attached to this feature (Tischler, 1915, Schürhoff, 1926, Clausen, 1927, Schnarf, 1931). But it should be remembered that it occurs in widely separated families e.g., Helobiales and Compositæ and members of the same family may differ from one another in this feature.

(c) *Generative nucleus*.—The generative nucleus in the pollen grains of this plant is almost equal in size and has the same staining capacity as the vegetative nucleus. This is rather remarkable as the generative nucleus, in many angiosperms, is much smaller in size and has a different staining capacity than that of the vegetative nucleus.

(d) *Shedding of the pollen*.—In *Artabotrys* the pollen grains are shed at the binucleate stage. Whether any systematic importance can be attached to this feature is doubtful (cf. Coulter and Chamberlain, 1909, Schürhoff, 1926, Wulff and Maheshwari, 1938).

Again, in *Artabotrys*, two pollen grains with three nuclei were observed. But the fact that all these three nuclei were small, of the same size and of the same staining capacity indicates that these do not represent the vegetative and the two male nuclei.

(e) *Size of the pollen grains*.—In *Artabotrys* different sizes of pollen grains are occasionally met with in the same flower bud. Such a dimorphism in the pollen grains is reported in *Gossypium*, *Zea Mays*, many Boraginaceæ (Singh, 1931), *Antigonon* (Rao, 1936), Amaranaceæ (Kajale, 1940), *Portulaca* (Kajale, 1942) and several other plants (Wodehouse, 1935).

Several workers (Singh, 1931, Wodehouse, 1935) believe that pollen dimorphism is indicative of hybrid origin.

⁴ From the unpublished work of the authors.

(f) *Germination of the pollen grains "in situ."*—Some pollen grains are reported to germinate when they were still inside the undehiscent anther of this plant. Similar instances of pollen grains germinating in the anther sac are reported in *Viscum album* (Schürhoff, 1922), *Rumex crispus* (Dudgeon, 1918), *Phaseolus vulgaris* (Weinstein, 1926), *Heliotropium supinum*, *Gastrocotyle hispida* (Singh, 1931), *Moringa oleifera* (Puri, 1941) and many cleistogamous flowers.

(g) *Archeporium and parietal layers in the megasporangium.*—Different views have been expressed by different workers about the archeporium in the family Anonaceae.

Oes⁴ (1914) and Juliano (1935) have found that the archeporium is deeply seated and the latter believes that it never divides to form any parietal cell. Schnarf (1931), however, has shown that it arises in the first hypodermal layer and then separates a primary parietal cell in this family. The observations recorded here support Schnarf's conclusion.

(h) *Bluish black mass at the chalaza.*—The chalazal tissue of the nucellus is found to be nutritive in function in a number of plants. Such cells with rich cytoplasmic contents have been observed in species of *Scoparia* (Schertz,⁵ 1919), *Costus* (Banerji, 1940), *Limnanthemum* (Srinivasan, 1941) and some Apocynaceae (A. Rau, 1940). *Artabotrys* also shows similar cells and it is highly probable that the embryo sac derives nutrition from them.

(i) *Development of the embryo sac.*—Maheshwari (1937, 1941) has given a very comprehensive review of the different types of development of embryo sac in angiosperms. He has described the monosporic octonucleate type of the embryo sac as the "normal" and the most primitive type, from which all other types have been derived. *Artabotrys* shows a "normal" type of development of the embryo sac and this type is also observed in *Magnolia* and *Liriodendron* belonging to the allied family Magnoliaceae (Maneval, 1914).

(j) *Antipodals.*—Antipodals are small and ephemeral in *Artabotrys*. Schnarf (1931) considers this to be characteristic of the family Anonaceae. It will be interesting to compare the conditions of the antipodals in the allied families. According to Schnarf (1931) Magnoliaceae shows such ephemeral antipodals; but Ranunculaceae, Menispermaceae and Berberidaceae show great activity of the antipodal cells (Coulter and Chamberlain, 1909, Joshi, 1939, Johri, 1935c).

(k) *Starch grains in the embryo sac.*—The presence of starch in the embryo sac has been reported in many plants (Dahlgren, 1927, 1939). Maheshwari (1931) is inclined to believe that the occurrence of starch is due to delayed fertilization.

(l) *Degenerations.*—Cases of degenerations were frequently observed in the pollen grains and ovules of *Artabotrys*. They were not mere cases of artefacts, as the nuclei in the tissues besides them were perfectly

⁴ As cited by Schnarf (1931).

⁵ As cited by Srinivasan (1940).

normal and appeared in strong contrast with the degenerated structures. Numerous cases of such degenerations have been reported in different plants and are considered to be indicative of the hybrid nature of the plant.

V. SUMMARY

The family Anonaceæ, being closely allied to the Magnoliaceæ, and possessing many monocotyledonous characters, required a thorough reinvestigation. The present paper embodies the observations on the structure and development of micro- and megaspores and their gametophytes in *Artabotrys odoratissimus*.

Four groups of archesporial cells in an anther are produced by sterilization of the two original groups. The outer cells of each group of the archesporial cells form the parietal and the sporogenous cells. 5-6 parietal layers are observed in the plant. The tapetum is not sporogenous in origin. Its cells become bi-nucleate by mitosis. Only a faint tendency towards the formation of periplasmodium has been noticed. The generative nucleus finally possesses the same size and staining capacity as that of the vegetative nucleus. The pollen grains are shed at the bi-nucleate stage. The entire loculus of the anther is occasionally seen to be filled with giant pollen grains. The pollen grains are psilate; they appear boat-shaped and monocolpate when examined by aniline oil gentian violet method.

The formation of the parietal cells from the archesporial initial takes place early in the ovule. The maximum number of parietal layers in the ovule is 8-9. A bluish black mass is observed at the chalazal end. Probably the embryo sac derives nutrition from them. The ovule is two-integumented. The micropyle is formed by the inner integument only. After fertilization, the dark stained contents are observed in the outermost layer of the outer integument and the innermost layer of the inner integument. The development of the embryo sac is of the normal type. The cells of the egg apparatus are variable in form. The synergids are short-lived. The antipodals do not increase in size and number. They disorganise early. The polar nuclei fuse late and have no fixed position in the embryo sac. The degeneration of the pollen grains as well as ovules have been frequently observed, possibly indicating the hybrid nature of the plant.

In conclusion, the authors feel highly obliged to Professor B. Sahni, F.R.S., Dr. P. Maheshwari, Dr. T. S. Mahabale and Dr. A. C. Joshi for valuable suggestions, criticism and help in literature.

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THE ALGAL FLORA OF THE HOT SPRINGS OF VAJRESHWARI, NEAR BOMBAY

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THE biological flora of hot springs is almost entirely algal and is composed principally of members of the Myxophyceae. These simple forms, though among the lowest in the plant kingdom, are nevertheless of great interest, as they are able to thrive in highly heated and mineralized waters under conditions inhibitory to other forms of life. According to some workers (Weed, 1889), such algae are very similar to the first forms of life to appear on the earth. In early geological times, when the crust of the earth was covered with waters of high temperature, it is conceivable that only such organisms could have flourished. However it is impossible to decide definitely whether the present vegetation of hot springs is identical with the vegetation of the earth during its early history, or whether these forms have adapted themselves specially to these conditions, as maintained by Elenkin (1914), Vouk (1923, 1929) and others. It has been affirmed that these algae can withstand a temperature of 85°C (Elenkin, 1914) or even 97°C (Brewer, 1866); but according to Vouk (1923) such statements are probably incorrect. Setchell (1903) has placed the upper temperature limit at 75°—77°C. The maximum given by Tilden (1898) is 69°C. Gepp (1918) speaks of them growing in hot overflows at temperatures between 60° and 70°C. It seems safe to assume that they can thrive up to 70°C; but all assertions of their growth above this limit should not be easily accepted.

The hot springs of India have attracted the attention of observers since a very long time. An early attempt at mapping these springs was made by Buist (1852). However the first comprehensive list was given by Oldham (1882) in a pamphlet, which supplied a great deal of information on the subject. He recorded no less than 301 such groups of springs in India and about 23 groups in the Konkan alone.

Thermal and mineral springs and geysers in particular, are a feeble manifestation of volcanic energy and abound particularly in regions of active and extinct volcanoes. They may also occur in non-volcanic regions, due to water having penetrated at a high temperature to deep-seated strata. In such a case, the temperature of the water depends on the depth from which it rises.

The vegetation of hot springs has been extensively studied in practically every country where such springs are found; but the flora of thermal springs in India has been almost entirely overlooked, though Steichen and Sierp (1911) mention the presence of large amounts of algae in such springs and advocate a study of them. This investigation

was therefore undertaken as a preliminary step towards a detailed study of the flora of the hot springs of the Bombay Presidency.

The Vajreshwari or Vajrabai springs are situated 48 miles to the north of Bombay in the Thana District which is rich in thermal springs. The geographical co-ordinates of the place are Lat. $19^{\circ} 29' 39''$ Long. $73^{\circ} 6'$. The Tansa river runs through the district and the springs are dotted on either side of the river. They are also found in the river bed. Within a circuit of a few square miles, about four to five groups comprising upward of 20 springs may be counted. Of these, only a few are easily accessible.

Collections of algae were only made from the springs near the Vajreshwari temple and from another group in the neighbourhood of a Spa which has been built for the treatment of patients suffering from various diseases. Algae were also collected from hot overflows from the streams, from the sides of built-in tanks or baths and from all waters where the temperature was higher than normal. The temperature of the hottest spring in these groups is 57.5°C . It forms a circular pool about 6 feet in diameter and about 3 to 4 feet in depth. The water is quite clear, and wells up from the spring at the rate of nearly 30 gallons per minute. The other pools formed from the springs are similar, but may differ in dimensions, temperature and the amount of water given off per minute. The underlying rock consists of basalt with laterite which is often decomposed due to the high temperature of the water.

The algae growing in waters of high temperature are found there, merely because they possess the ability to withstand these temperatures. Such algae are of two types viz. those which live exclusively in hot water and those which can exist both in hot and cold water. At 57.5°C a species of *Anabaena* was found occurring both at the sides of the pool and in the overflow from it. Though collections were made on several occasions, spores were never found. It seemed to be a strictly thermal alga as it was never found at lower temperatures. At 55°C was seen *Phormidium africanum* Lemm. This form was able to endure a wide temperature variation and occurred even at 40°C . *Phormidium orientale* West was found between 38°C . and 49°C . A peculiarity of this form is its copious secretion of mucilage. The threads were exceedingly slender, but they were embedded in mucilage, forming watery jelly-like masses. *Plectonema gracillimum* (Zopf) Hansg. occurred at 49°C , but it was seen in one collection at this temperature, and not at lower temperatures. *Oscillatoria jatorvensis* Vouk was able to endure a temperature range of 40°C to 49°C . Together with it, colonies of *Aphanocapsa thermalis* Brugg. were seen enduring the same temperatures. The colonies were usually small, though sometimes they became fairly large. In small colonies, the cells were tightly packed together. *Lyngbya putealis* Mont occurred between 40°C . and 45°C . Of the algae just mentioned, probably only *Phormidium orientale* and *Aphanocapsa thermalis* are definitely thermal forms. The others are also found in cold waters.

At lower temperatures, a number of other algae was seen. A few filaments of *Spirulina subsalsa* Oerst. together with *Oscillatoria proboscidea* Gom. were found at 38°C . Between 34°C and 36°C were seen *Scytonema tolypatrichoides*, Kütz., *Lyngbya aestuarii* (Mert) Lieb., forma *spectabilis*

Gom., *Gloeocapsa granosa* (Berk) Kütz and *Anabaena orientalis* Dixit. A species of *Aulosira* was seen together with *Gloeocapsa granosa* in all stages, including spore formation and spore germination, so that its life history could be studied. It is a new species and has been described in another paper as *Aulosira bombeyensis*. Diatoms were never observed in the actual springs, but in the overflows, two diatoms viz. *Nitzschia thermalis* Kütz and *Rhopalodia gibberula* (Ehr) O. Mull were seen. The latter showed slight variations in its form and dimensions, due probably to the environmental conditions.

Of all the forms described above, *Phormidium africanum* was the most common and was observed in almost every spring or overflow with a temperature between 40°C and 54°C, even if these were situated at considerable distances from one another. Other common forms were *Phormidium Orientale* and *Oscillatoria jatorvensis*.

SYSTEMATIC ENUMERATION OF THE SPECIES OBSERVED CYANOPHYCEAE

Order	CHROOCOCCALES
Family	<i>Chroococcaceae</i>
Genus	<i>Aphanocapsa</i> Naegeli

1. *Aphanocapsa thermalis* Brugg. Geiteer, in Rabenhorst's *Kryptogamenflora von Europa*, Band XIV Cyanophyceae, 1930-32, p. 159
Lat. cell., 3.2—4u.

Habitat :—With *Phormidium Africanum* Lemm in an overflow from a spring between 40°C and 49°C.

Genus *Gloeocapsa* Kützinger

2. *Gloeocapsa granosa* (Berk) Kütz. Geitler, op. cit., 1930-32, p. 188, Fig. 84.

Forma

Lat. cell., 3.2—4.8 u ; Lat. cell. cum. vag., 12 u.

Habitat :—With *Aulosira Bombayensis* on the wall of a tank at 34°C. The form differs from the type in the many-layers sheaths.

HORMOGONEALES

Family	<i>Microchaetaceae</i>
Genus	<i>Aulosira</i> Kirchner

3. *Aulosira Bombayensis* Gonz., Gonzalves in "A new species of *Aulosira*," Iyengar Comm. Volume, 1946.

Lat. trich., 2.4—3.4 u ; lat : fil., 5 u ; Lat. het., 3.4—5 u ; long. het 8.—12.8 u. Lat. spor., 4.6—6.4 u ; Long. spor 6.4—12.8u.

Habitat :—On the wall of a tank at 34°C.

Family *Scytonemataceae*Genus *Plectonema* Thur.

4. *Plectonema gracillimum* (Zopf) Hansg. Geitler, op. cit., 1930-32, p. 694.

Lat. fil., 2.4—3.2 u ; Lat. trich., 1.2—1.6 u ; Long. cell 3.2—4 u.

Habitat :—Temple Tank at 49°C.

Genus *Scytonema* Agardh.

5. *Scytonema tolypotrichoides* Kütz. Geitler, op. cit., 1930-32, p. 779, Fig. 500.

Lat. fil., 10.5—14 u ; Lat. trich., 8.2—11.4 u ; Lat. het., 8.8—12 u.

Habitat :—In an overflow from a spring in the grounds of the Spa at 36°C.

Family *Nostocaceae*Genus *Anabaena* Bory.

6. *Anabaena* sp.

Lat. cell., 2.7 u ; long. cell., 3.7 u ; lat. het., 2—2.7 u.

Habitat :—In the hottest springs at 57.5°C.

Further observation of this alga is necessary as it is most probably a new species.

7. *Anabaena orientalis* Dixit. Dixit, The Myxophyceae of the Bombay Presidency, India, I, 1938, Proc. Ind. Acad. Sci., Vol. I, p. 101 Fig. 3, D and E.

Lat. cell., 4—4.8 u ; long. cell., 4.8—6.4 u ; lat. het., 6.4 u ; long. het., 9.6 u ; lat. spor., 7.2—9.6 u ; long. spor., 14.4—17 u.

Habitat :—At 34°C in an overflow from a spring.

The cells are slightly larger in dimensions than the type.

Family *Oscillatoriaceae*Genus *Spirulina* Turpin

8. *Spirulina subsalsa* Oerst. Geitler, op. cit., 1930-32, p. 927, Fig. 593a
Lat. trich., 1.6 u, lat. spir., 3.2 u.

Habitat :—With *Oscillatoria proboscidea* Gom at 38°C in an overflow.

Genus *Oscillatoria* Vauch.

9. *Oscillatoria proboscidea* Gom. Geitler, *op. cit.*, 1930-32, p. 943, Fig. 598 b.

Forma

Lat. trich., 9.4 u ; long. cell ; 3.2 u.

Habitat :—In an overflow near the Spa at 38°C.

This form is slightly narrower than the type.

10. *Oscillatoria jatorvensis* Vouk. Geitler, *op. cit.*, 1930-32, p. 962, Fig. 613.

Forma

Lat. trich., 4—4.4 u ; long. cell., 2.4—3.2 u.

Habitat :—In springs and overflows near the Spa at 40°—49°C.

It is slightly broader than the type.

Genus *Phormidium* Kütz.

11. *Phormidium Africanum* Lemm. Geitler, *op. cit.*, 1930-32, p. 999. Lat. fil., 2.7 u ; lat. trich., 1.2—1.9 u ; long. cell., 5.6—7.5 u.

Habitat :—In various springs and overflows between 40°C and 54°C.

12. *Phoridium Orientale* G. S. West. Geitler, *op. cit.*, 1930-32, p. 1010 ; G. S. West, Some Algae of Hot Springs, Jour. of Bot., p. 248, Pl. 438, Fig. 25—27.

Lat. fil. 1.6—2 u ; long. cell. 6.4 u.

Habitat :—In overflows between 38°C and 49°C.

Genus *Lyngbya* Agardh

13. *Lyngbya aestuarii* (Mert) Liebm. forma *spectabilis* Gom. Geitler, *op. cit.*, 1930-32, p. 1052, Fig. 666.

Lat. fil., 38.6—41.5 u ; lat. trich., 24-27.7 u ; long. cell 5—6 u.

Habitat :—In overflows between 34°C and 36°C.

14. *Lyngbya putealis* Mont. Geitler *op. cit.*, 1930-32, p. 1063, Fig. 675 b.

Lat. fil., 9.3 u, Lat. trich., 5.6—7.5 u.

Habitat :—In the temple tank and overflows between 40° and 45°C.

BACILLARIOPHYTA (DIATOMEAE)

Order PENNALES

Sub order BIRAPHIDINEAE

Family Epithemiaceae

Sub family Rhopalodioideae

Genus *Rhopalodia* O. Muller

15. *Rhopalodia gibberula* (Ehr.) O. Mull. Hustedt, Fr., Pascher's Susswasser—Flora, Heft. 10, 1930, p. 391, Fig. 742.

Length : Up to 33.6 u ; Breadth : 15 u ; Costae 4—5 in 10 u.

Habitat :—In overflow from a spring near the Spa at 40°C.

Family NITZSCHIACEAE

Sub family Nitzchioideae

Genus *Nitzschia* HassalSection *Dubiac* Grunow

16. *Nitzschia thermalis* Kütz. Hustedt, *op. cit.*, 1930, p. 403, Fig. 771.
Length : 123 u Breadth : 8.8—10 u ; Keel punctae 10—11 in 10 u ; Striae 25 in 10 u.

Habitat :—In overflow from a spring with the above at 40°C.

The identification of the algae in this work was made in the Botanical Laboratory of the Madras University and the author wishes to express her sincere thanks to Prof. M. O. P. Iyengar for his valuable help and for the facilities he placed at her disposal. She also wishes to thank Dr. Kothawalla of the Behram Spa, Vajreshwari, for his help in making the algal collections.

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A COMPARATIVE STUDY OF PERMEABILITY TO WATER OF THE SKIN IN SOME REPRESENTATIVE VERTEBRATES

By J. C. GEORGE

INTRODUCTION

IT is well known that the skin acts as a barrier structure in aquatic animals limiting the percolation of water and that this faculty of the skin is of utmost importance for existence in water. The skin of a terrestrial animal on the other hand restricts evaporation of water through it. The percolation of water through the skin in aquatic surroundings depends (apart from the difference in osmotic potential and other extrinsic factors) on its nature. It is believed that this nature of the skin as regards its permeability to water is dependent on the number and size of minute pores it possesses per unit area. The evaporation of water from terrestrial animals is also dependent on the pores present on the skin. The permeability of various types of skins to water can therefore be compared by using the same types of tests, and from the results obtained, the evolutionary trends as regards the particular feature can be ascertained.

EXPERIMENTS

The apparatus used for this purpose consisted of the equipment meant for conducting the usual thistle funnel experiment for demonstrating osmosis. The thistle funnel arm is graduated in millimetres. For purposes of accurate comparison, the experiments were conducted as far as possible under similar conditions. A solution of the non-hygroscopic salt potassium chloride was used in a concentration of 20%, prepared fresh every time, as the osmotic fluid. The rise in the thistle funnel above the basal mark was noted after the lapse of an hour every time. Ten readings for every type of skin used as the permeable membrane were taken and the mean ascertained. The two tables given below show the rise in the water column in the thistle funnel in one hour ; the first one relates to the rise while the inner surface of the skin was in contact with the salt solution and the second to the measurements taken with the outer surface in contact with the salt solution in the funnel.

1. *Mean of the readings taken when the interior of the skin was in contact with the salt solution in the funnel.*

<i>Skins Used</i>	<i>Rise in mm.</i>
Scoliodon	20
Arius	12
Rana	100·7
Calotes	4·5
Uromastix	2
Columba	6
Guinea pig	8·5

2. *Mean of the readings taken when the exterior of the skin was in contact with the salt solution in the funnel.*

<i>Skins Used</i>	<i>Rise in mm.</i>
Scoliodon	10.5
Arius	7.5
Rana	35.75
Calotes	5
Uromastix	3
Columba	4
Guinea pig	9.5

Another series of experiments conducted with a view to see if frogs can be acclimatised to sea water consisted of keeping two frogs at a time in a bucket with two gallons of fresh water and replacing two pints of the water every morning with sea water. The experiment was repeated ten times. It was found that frogs cannot be acclimatised to sea water. They died after 92 to 129 hours. Frogs transferred directly to sea water died within 4 to 5 hours. These experiments have a bearing on the nature of the skin in frogs.

DISCUSSION

The conclusions that one may draw from the osmosis experiments and those of keeping frogs in water gradually made more concentrated with sea water are far reaching. The experimental study of the skin using it as a membrane is rather recent though Stirling (1877) and Donaldson (1901) reported that frogs absorb water through their skin. Maxwell (1913) supported the earlier findings. Przylecki (1923) showed that the skin of the frog containing a one per cent solution of sugar would not allow it to pass through but if the sugar solution is on the outside it would get through the skin. This gives a disparity in results when the direction of flow is changed. The significance of this variation requires examination.

Fredrieq has found that the osmotic pressure of the body fluids in marine elasmobranchs is almost similar to that of sea water. From that he had drawn the conclusion that this group of fishes are very near the ancestral vertebrate stock which arose in the sea. This view, however, is contrary to the view expressed by Romer and Grove that the Ostracodermi and the ancestral chordates originated in fresh water habitats. The flow into the body from without is double that of the flow outwards in the Scoliodon which is a marine elasmobranch. The skin therefore allows water to percolate through it to the interior if at any time the internal osmotic pressure increases. On the contrary if the internal pressure decreases there is provision for a slower flow of water to the outside. This will also facilitate a migration into relatively less saltish waters though Scoliodon is not known to migrate like Carcharius into estuaries and fresh waters.

In the case of the marine catfish Arius sp. the permeability is less than that in the shark. The osmotic pressure of the body fluids in marine teleosts has been found to vary between .85 and 1.05 which they maintain in spite of the surrounding sea water. Water is therefore likely to be drained from the body and this is offset perhaps by the taking in of salt and removing it through the kidneys. This confirms that there is osmoregulation in the marine teleosts and the skin is not kept perfectly

watertight though it is much more so than that of sharks. The teleostean skin is thus an advance on that of the elasmobranchs in restricting permeability, if all teleostean fishes are provided with almost similar skins to that in *Arius*.

The inward flow of water through the frog skin is greater than that known in any vertebrate. It is five times as much as that through the shark skin. The outward flow is also relatively very high. That means in the course of evolution the frog has taken a unique direction. The osmotic pressure of body fluids in the frog is similar to that of fresh water teleosts. While in the natural conditions of life there is practically no chance for a frog to be confronted with a medium with osmotic pressure higher than that of its body fluids, in its natural habitat an inward flow of water will cause a reduction in the osmotic pressure of its blood and lymph unless regulated. That this regulation takes place is certain since a frog throws out large quantities of water through its kidneys. Parnas has demonstrated that when the cloaca of a frog is artificially closed, absorption through the skin continues only for a short while and stops later. There must be some very important physiological principle involved in this acquisition by the frog of a highly permeable skin which adds considerably to the work of the kidneys. It cannot be a means for increasing the efficiency of the kidneys since without such a flush out the teleostean kidney in freshwater forms can function adequately.

Unlike the fresh water teleost the frog has to breathe through its skin and since being a less actively moving creature, it has to get all its oxygen supply when immersed in water through the skin from the comparatively unchanging medium around it. This it does through the water taken in from the surroundings. A possible explanation for taking in such a steadystream of water from the outside is that it is respiratory. It is well known that animals like the echinoderms and coelenterates which are washed in and out by sea water take in most of their necessary oxygen from the water, directly into their tissues. On that analogy a constant flush out of the body means respiratory exchange. The drawn-in water therefore is a respiratory current. Such a view is often not expressed with regard to the respiration of the frog, as the outside oxygen is supposed to diffuse directly into the blood-vessels of the skin. The present explanation, however does not preclude the possibility of diffusion from and into the body, of the respiratory gases.

A word of explanation is also necessary as regards the respiration when it is exposed to the atmosphere. Under these conditions a direct osmosis of the gases is the only possibility. This mode of respiration is more efficient than when the frog is submerged as the supply of oxygen is the highest in the atmosphere. Osmoregulation during this period takes place through the water stored up in the bladder.

The explanation for the dying of frogs in sea water can also be found in the skin. When directly plunged in sea water a flow of water from the subcutaneous lymph spaces takes place as the outside medium is now in a higher osmotic pressure. This upsets respiration and also increases the acidity of the body fluids. In other words the whole metabolism of the animal is upset and like most lower vertebrates it dies quickly since it lives on the margin of safety. A more gradual upsetting of metabolism takes place when the animal is exposed to water the salinity of which is gradually increased.

Here I may record the results of an attempt made a couple of years ago to breed frog tadpoles in water the salinity of which was gradually increased. The toleration of salinity was only for the lowest degrees and as the percentage of salt was increased in the medium they died.

The frog is thus a unique animal as regards the porosity of its skin. This is borne out by the results of the thistle funnel experiments. Such a skin is most unsuitable for life in the marine or brackish waters. But it is the first step in the formation of the terrestrial skin from which drying is prevented by mucus formation, and at the same time it is respiratory.

The life of a terrestrial animal like the reptile is entirely different from that of an aquatic one. Since the lungs are better developed in reptiles the skin need not contribute much towards respiration. The main function of the skin is therefore protection of the intra-cutaneous tissues. Since these animals mostly live away from sources of water, they have to conserve a good deal of water in the body for osmoregulatory purposes. For such a purpose therefore a dry skin which does not allow any evaporation from the body is the best. Such a conclusion is borne out by the osmosis tests conducted by me, as in *Uromastix* and *Calotes* the outward flow is 3 mm and 5 mm respectively in one hour compared to 35 mm in the frog. Apart from the general keratinisation of the skin, the formation of scales adds to the imperviousness of the skin. The reptilian skin therefore is highly protective and impervious, but from the metabolic standpoint it is a retrograde evolutionary step.

In this connection it may be pointed out that the skin of *Uromastix* is less pervious than that of *Calotes*. This is also to be inferred from the nature of the skin and the habitats of the two animals.

The lizards show curiously enough greater outward than inward flow. I am at a loss to account for the phenomenon.

The skin of the pigeon is also very much less permeable to water than that of the frog. In this animal also it is the keratinised outer layer which bestows on it the impermeability. The greatness of the bird lies greatly in its epidermal outgrowth system which is very much more gorgeous and elaborate than that of the reptile.

The porosity of the mammalian skin is greater than that of the birds and reptiles. This means a going back on the protective reptilian mode of evolution of the skin. The reptilian skin meant more isolation from the environment as opposed to the amphibian skin. The mammalian skin means more co-operation with the environment, this time with the dry atmosphere and not with the watery medium of the amphibians. Moreover the wholesale keratinisation of the epidermis met with in the reptiles and birds has been abandoned for allowing room for some epidermal glands—a feature now revived from the amphibian stock. The glands in the amphibian epidermis are meant to keep the skin moist, while the glands in the mammals serve two important functions, excretion and maintenance of temperature. The mammalian skin is thus a highly evolved physiological structure unlike the arid protective membrane of the reptiles.

In all the experimental animals except the lizard there was greater amount of osmosis of water when the outer surface was in contact with it than when the inner surface was exposed to it. This difference in behaviour is explained by assuming the existence of a force exerted by the skin, called *electrosmosis* by Adolph. This force is probably exerted by

the dermis which attracts water inwards when the outer surface is in contact with it. The passage of water under the circumstances is due to the combined action of osmotic pressure and electrosmosis. When the inner surface is in contact with water outside, the flow inwards is less since the force of electrosmosis now acts against the osmotic pressure.

SUMMARY AND CONCLUSIONS

All vertebrate skins are to a greater or lesser extent permeable to water. Those of terrestrial vertebrate classes are on the whole less permeable than those of aquatic ones.

Among the aquatic vertebrate groups the elasmobranch skin is more porous than the teleostean. The reduction in permeability in the latter is traceable to thicker and more closely knit tissue structure. This type of skin helps teleosts to regulate the osmotic pressure of their body fluids.

The frog skin has been found to be the most permeable of vertebrate skins. From observations of others and also of mine it can be safely concluded that the aquatic life of a frog is dependent on maintaining a regular current of water into the body from outside. Probably this water current is respiratory.

The reptiles and birds show little permeability in their skins. Permeability is reduced by keratinisation of the epidermis which in the former can be sloughed off as a sheath. The loss of permeability helps these animals to conserve water as very little evaporation takes place from the surface of the skin.

In the mammals there is a reversal to increased permeability to water accompanied by less uniform keratinisation of the epidermis and development of epidermal glands. As a consequence there is more evaporation from the surface which helps to regulate temperature.

The permeability to water from without inwards, that is when the outer surface was in contact with water was found to be greater than when the inner surface was in contact with water outside in all the animals experimented except the lizard. Probably a force called electrosmosis ascribed to certain living membranes explains this difference. This force is probably exerted by the dermis, which tends to draw water inwards when the outer surface of the skin is in contact with the water. At this time the passage of water through the skin is due to the combined action of osmotic pressure and electrosmosis. When the inner surface is in contact with water outside, the flow inwards is due to the difference between osmotic pressure and electrosmosis.

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THE EVOLUTIONARY SIGNIFICANCE OF THE VARIATION IN THE CHEMICAL COMPOSITION OF THE SKELETAL MUSCLE IN THE VERTEBRATE SERIES OF ANIMALS

By J. C. GEORGE

INTRODUCTION

THE contractility of protoplasm so characteristic in the Protozoa is manifested in evolution in a more pronounced manner in the muscle cells. Wherever movement is necessary in the higher animal groups this contractile tissue is utilised for the purpose. Through the ages as simple animals gave rise to more complex ones, the muscle cells also evolved in various ways. In the more advanced types of muscle cell, the contractile substance is more differentiated, while in the primitive types there is more undifferentiated protoplasm. For example in the wing muscle of insects which are meant for rapid contraction and relaxation, the cross-striation and fibrillar arrangement are most marked. In the muscles of the Ammocete larva on the other hand, there is more undifferentiated protoplasm and the nuclei are arranged as in ordinary cells towards their centre.

From the physiological point of view the two types of muscles, the voluntary and involuntary are the end products of evolution on two distinct lines in relation to the nervous system. Each of these has its peculiar architecture, physiological properties, location and associations. While the voluntary muscles are concerned with the movements of the organism in adjusting itself to the necessities, vicissitudes and other conditions of the environment, the involuntary are mostly concerned in the movement of the internal organs. The most important of the involuntary muscles is the cardiac muscle with remarkable properties.

While the diversity in the structure and relations of the muscles in the various animal groups has been somewhat well known, at least are clearly explainable, the evolution of the muscular system in its chemical and functional implications in the various animal groups has been only very meagrely appreciated. For example the peculiar bodies called sarcosomes met with in insect muscle, though known for sometime, are not definitely ascribed any proper functions. Similarly the function of myoglobin in the red muscle is not well understood. Nor are the variations in the chemical composition and their probable significance explained satisfactorily.

The muscle tissue contains water, proteins, carbohydrates, lipoids and inorganic salts. Though carbohydrates and fats are the main sources of energy these substances are found only to a limited extent in

the muscle. On the contrary the muscle cell contains more proteins; 18 to 20% of the muscle is protein. Lipoids are found between 1 and 2.5%. Glycogen, the chief carbohydrate in muscle occurs between .576 and .709 in the cardiac muscle of the dog; in the skeletal muscle of the animal, however, it is only .15 to 3%. The muscle tissue of the various vertebrate groups differs considerably. The chief constituent of all muscles is water. Next comes proteins. The proteins of the various groups are different and there is likely to be more variation in this respect than agreement. This is emphasized in the following quotation from Mathew's physiological chemistry. "The proteins of the muscle are characteristic and indeed, the muscle of each species of animals has its own specific protein. Probably were our methods fine enough, we should find the proteins of each individual of the same species to be different from the corresponding protein in other individuals." The latter part of the quotation may be an overstatement; the more probable will be that among a species there will be subspecies or varieties which may differ in the composition of their muscle proteins.

The chemical composition of the muscle is related to its peculiar metabolism. In a mammal 50% of its metabolism at a time of rest is muscular and at a time of muscular activity it amounts to 75%. The formative metabolism or anabolism of a muscle is mainly its protein metabolism since proteins are the major constituents of muscle. Likewise its catabolism is also mainly one of protein catabolism. The former takes place during growth, while the latter during starvation. Apart from this formative and catabolic metabolism, there is a second type of metabolism associated with the contraction and relaxation of muscle. The two types of metabolism are under the control of two different sets of nerves in the vertebrates. The formative metabolism is under the influence of the sympathetic, while the contractile type is controlled by the spinal nerves. Dart is of opinion that the latter form of metabolism is superimposed on the former which is more primitive than the first one. How far such an interpretation is on sure ground is doubtful since in Hydra and other coelenterates where the contractile tissue makes its first appearance, muscular contraction is under the control of diffused nerve cells. Such is the case in many invertebrates higher than coelenterates, whose nervous system is more of a sympathetic than a central one.

From all these standpoints it is immensely profitable to undertake a detailed chemical investigation of the muscle tissue in the vertebrates. Such a study involving representatives of the different classes of vertebrates will throw considerable light on the physiological evolution of the vertebrates. The present is a preliminary attempt in that respect. Even this is handicapped by want of literature dealing with similar studies elsewhere though such are few indeed. Nevertheless the investigation being perhaps the first of its kind in India will, I hope, be of some use in future to understand the problem of physiological evolution of vertebrates.

EXPERIMENTS

The present investigation consists in ascertaining the amount of water, total solids, proteins, lipoids, salts, and carbohydrates, in the fish, frog, lizard, bird and mammal muscle. The animals selected for

the purpose are respectively, *Batrachus*, *Rana*, *Uromastix*, *Columba*, and *Cavia* (guinea pig.)

For determining the amount of water, a fresh quantity of muscle about one gram was taken. This is weighed in an evaporating dish. The dish with its contents was transferred then to an air oven kept at a temperature of 100°C to 150°C. The tissue was dried till it maintained a constant weight. The difference between the original weight and that after drying gave the weight of water. The amount of water per 100 gm. of muscle was then calculated.

For determining the total solids present in the muscle the weight of water was subtracted from the original weight of the muscle taken.

For determining the amount of protein present in the muscle, a small quantity of fresh muscle (about .2 gm.) was weighed out in a watch glass and transferred to a long-necked pyrex Kjeldahl flask into which 5 cc. of nitrogen-free concentrated sulphuric acid, 1 gm. of potassium sulphate and .2 gm. of copper sulphate were then added. The flask was then heated on low flame for some time. Then contents of the flask became charred. The flame was then increased. After a while the black stuff became a water-clear solution. Heating was continued for a further half-hour. The flask with its contents was then allowed to cool. When cold the contents of the long-necked flask was thoroughly washed with ammonia-free water into the large conical flask of a K. distillation unit. An excess of 30 to 40 cc. of 50% NaOH were then added to the contents in the conical flask.* The excess of NaOH was indicated by the solution turning deep blue owing to the CuSO_4 present. A few pieces of granulated zinc were added to avoid bumping. The mouth of the flask was attached to one end of the distiller and the flask was heated. The other end of the distiller was connected to a short rubber tubing and that was in turn joined to the glass tube with a bulb. This tube was made to just dip into 25 cc. of 0.1N sulphuric acid kept in a conical flask. Two or three drops of methyl red were added to the sulphuric acid in the conical flask. Ammonia evolved was thus allowed to pass into the .1N sulphuric acid. Bubbles were seen coming on the surface of the sulphuric acid. This was allowed to go on for some thirty minutes by which time all ammonia would have distilled over. Then the apparatus was disconnected and the distillate (with the standard acid solution kept for absorbing the liberated ammonia) was boiled to remove carbon dioxide, cooled and finally the excess of acid was titrated against carbon free 0.1 N sodium hydroxide Solution, methyl red added serving as an indicator.

The principle involved in this method is as follows. All the nitrogenous material in the muscle was converted into ammonium sulphate by boiling with concentrated sulphuric acid. Potassium sulphate was added to hasten the acid digestion by raising the boiling point. When 50% NaOH was added in excess the acid present is neutralised. On heating the ammonium sulphate formed gives off its ammonia which was collected in an acid of known strength. From the amount of ammonia the nitrogen in the muscle can be ascertained. The amount of nitrogen multiplied by the factor 6.25 gives the amount of protein.

The calculation is done as follows. Suppose the weight of muscle taken is 0.205 gm. The Volume of standard (0.1N) sulphuric acid taken for receiving the ammonia evolved is 25 cc. The Volume of standard (0.1N) sodium hydroxide required to neutralise the excess of sulphuric acid is 20.8 cc. The difference between the quantity of alkali required for neutralisation and the amount of acid taken (25 cc.—20.8 cc.) is a direct measure of the ammonia evolved. That is, 0.205 gm. of muscle can give rise to 4.2 cc. of 0.1N NH_3 . That is, 4.2 cc. of 0.1N of N_2 . That is again, 4.2×0.0014 gm. of N_2 . Therefore in 100 gm. of muscle

the amount of nitrogen is $\frac{4.2 \times 0.0014 \times 100 \text{ gm.}}{0.205}$ The protein content of 100 gm. of muscle is $\frac{4.2 \times 0.0014 \times 100 \times 6.25 = 17.92 \text{ gm.}}{0.205}$ The percentage of protein in that sample of muscle (of the frog) was 17.92.

For determining the percentage of fats or lipoids in the muscle, about five grams of completely dehydrated muscle was taken in a Soxhlet extraction apparatus, after first ascertaining the weight of its receiving flask. The muscle was then subjected to continuous extraction with anhydrous ether for about eight hours. The contents of the receiving flask were freed from all remaining ether by heating it first in a water bath and then in an air oven. The flask was then cooled and weighed. The increase in the weight of the flask gave the amount of fat in that quantity of muscle. To ensure the total extraction of fats, the process of extraction was continued till there was no longer any increase in the weight of the receiving flask and its contents. The fat content of the fresh muscle could be calculated as the water content of the muscle was known before hand.

The ash content of the muscle was obtained as follows. A crucible with lid was first weighed. About one gram of muscle nicely pulped was weighed in the crucible with lid. The crucible was then heated at a temperature below redness until the ash was completely free from carbon; that is till the crucible showed a constant weight. This weight minus the weight of the crucible gave the amount of ash in the sample of pulp taken. The percentage content was then calculated.

The carbohydrate content in a muscle is very small and moreover its amount varies according to the physiological conditions of the muscle. From the weight of total solids, the combined weight of proteins, fats and ash is subtracted, the remainder is the weight of the carbohydrates present. This method of obtaining the percentage of carbohydrate in muscle by calculating the difference after ascertaining other constituents is generally adopted.

The experiments in each case were repeated five times, and the following tables give the mean of the results obtained.

WATER CONTENT IN THE BODY OR THIGH MUSCLE OF SOME VERTEBRATES

<i>Animal</i>	<i>Water content in 100 gms. of muscle</i>
Batrachus (fish)	80.90 gms.
Rana (frog)	79.30 „
Uromastix (lizard)	78.43 „
Columba (bird)	71.79 „
Cavia (guinea pig : mammal)	75.50 „

TOTAL SOLIDS IN THE BODY OR THIGH MUSCLE OF SOME VERTEBRATES

<i>Animal</i>	<i>Total solids in 100 gms. of muscle</i>
Batrachus	19.10 gms.
Rana	20.70 „
Uromastix	21.57 „
Columba	28.21 „
Cavia	24.50 „

PROTEINS IN THE BODY OR THIGH MUSCLE OF SOME VERTEBRATES

<i>Animal</i>	<i>Proteins in 100 gms. of muscle</i>
Batrachus	16.00 gms.
Rana	17.83 gms.
Uromastix	18.20 gms.
Columba	23.06 gms.
Cavia	20.60 gms.

FATS IN THE BODY OR THIGH MUSCLE OF SOME VERTEBRATES

<i>Animal</i>	<i>Fats in 100 gms. of muscle</i>
Batrachus	1.21 gms.
Rana	0.90 gms.
Uromastix	1.40 gms.
Columba	2.74 gms.
Cavia	1.86 gms.

ASH IN THE BODY OR THIGH MUSCLE OF SOME VERTEBRATES

<i>Animal</i>	<i>Ash in 100 gms. of muscle</i>
Batrachus	1.30 gms.
Rana	1.27 gms.
Uromastix	1.30 gms.
Columba	1.20 gms.
Cavia	1.40 gms.

CARBOHYDRATES IN THE BODY OR THIGH MUSCLE OF SOME VERTEBRATES

<i>Animal</i>	<i>Carbohydrates in 100 gms. of muscle</i>
Batrachus	0.59 gm.
Rana	0.70 gm.
Uromastix	0.67 gm.
Columba	1.20 gm.
Cavia	0.64 gm.

Mention should be made that in the case of the fish the muscle tested was from the lateral region behind the pectoral fins, that is from the region which is exercised in movement. In the case of the frog, lizard, and guinea pig the thigh muscles have been used. In the case of the bird the pectoral muscles used in flight have been utilised. In all these cases thus the active muscles have been chosen.

Discussion.—Many records on the chemical composition of the mammalian muscle are available. Likewise the general composition of many species of fish is known. Furth (1896 to 1903) in a series of papers gave the composition of the muscle of ox. Baglioni (1906) gave an account of the composition of the muscle in the electric ray while comparing the chemistry of the muscle with that of the electric organ. Stewart and Sollman (1899) were some of the earliest to study the proteins of the muscle. The more recent references relating to the subject of muscle chemistry are given in the Annual review of Biochemistry by B. Eggleton (1935) Parnas (1932,33) Needham (1937) and Lundsgaard (1938). Enlightening as most of these are from the standpoint of muscle chemistry, the treatment has not been a comparative one and the records relate mostly to mammalian muscle. The recent references to fish muscle are on the nutritional value of fish. I have not come across a single paper on the comparative composition of muscle in the various classes of vertebrates. As regards the general composition of mammalian, amphibian and fish muscle, my figures compare favourably with those of earlier workers.

From a general analysis of the results the most outstanding fact is that the percentage of water in the flesh is greater in the Amphibia and fishes which are aquatic creatures and it is less in the terrestrial vertebrates. There is also a gradual decrease as we ascend from the fishes to the reptiles and from the reptiles to the birds and mammals. This shows that as animals become more and more terrestrial, their muscle-water requirement became progressively less.

The highest reduction is in the case of the birds. This is naturally to be expected as in the economy of a flying animal it is advantageous to minimise the weight of the body as a whole. The percentage in the reptile is 78.43, and that of the bird is 71.80. The reduction in the mammal is only to 75.5%.

Uromastix is a desert animal and perhaps one would expect to find a drastic reduction in the water content of its muscle. The results of the present investigation show that its heredity weighs more heavily on this animal than its habitat.

The weight of the total solids on the other hand increases as we ascend the ladder from the lower to the higher vertebrates. This shows that there is a general increase in the metabolism of the muscle from the fishes to the birds and mammals. So weight for weight the muscle of the higher vertebrates is more metabolic than that of the lower one.

The protein content of a muscle is a measure of its formative metabolism. According to this view the fishes stand on the lowest rung and the birds and mammals on the top rungs of the ladder. This means as evolution progressed the metabolic increase in the muscle of the advanced vertebrates was formative to a great extent.

The carbohydrate content of a muscle on the other hand is a measure of its contractile metabolism. What part the fats play in this type of metabolism is not known. As fats are convertible to carbohydrate one may perhaps take into account the sum of the carbohydrates and fats. If the carbohydrates alone are taken into account, excluding the birds, the frog muscle contains the largest amount. The highest figure for birds can be easily understood as the breast muscles do require a large store of the material to function properly in flight. The figures for other animals, however, are very near those of that frog.

If the combined weight of carbohydrates and fats is taken into account, the frog muscle shows 1.60% which is the least; next comes that of the fish which is 1.8%; the lizard shows 2.07, the guinea pig 2.44 and the pigeon 3.94. Taking into account the activities of these animals there is no doubt that the breast muscle of the bird is the most active and the large amount present in it can be well explained on that score. The guinea pig comes next in terms of activity especially as it is a warm-blooded animal; the 2.44% does not seem incompatible with the activity of this animal. *Uromastix* comes next with 2.07% and as it is a fast-moving animal, the figure is not unexpected. The frog is more sluggish than the fish, though *Batrachus* is not a very active fish; therefore the percentages of carbohydrates + fats in the muscle of these two animals are relatively low.

The figures for fats taken alone are also in accordance with the evolutionary trend; the only exception being the low figure of 0.90 for the frog. Accumulation of fat in the muscle is known to be a seasonal feature in the fishes, frog and probably it is so in the lizards. Fat is drained from various sources towards the fat body in the months preceding breeding in the case of the frog. Since the analysis was carried out during the months from November to March, when the fats are stored up in the fat bodies, the muscle fats might be less. Probably on the same score, the figure for *Uromastix* muscle is also lower than usual.

SUMMARY AND CONCLUSIONS

There appears to be a progressive reduction in the water content of the muscle in the vertebrates in accordance with the evolutionary level of the animals experimented. Thus the fish contains 80.90%, the frog, 79.3 %, the lizard 78.43%, the bird 71.80%, the mammal 75.50%. The lowest amount is in the bird. This is to be expected since in the economy on a flying animal it is essential to get its density reduced to the minimum without interfering with efficiency.

Though *Uromastix* is a desert animal the water content of its muscle is more than that of the guinea pig and only slightly less than that of the frog. Heredity is more powerful than habit at least in this particular instance.

The protein content which is a measure of the formative metabolism of muscle shows a corresponding increase when ascending from fish to bird and mammal. Thus the fish with 16.00% shows the lowest, the frog with 17.83% comes next, the lizard with 20.20% takes the next place, and finally the bird with 23.06%, and the mammal with 20.60%.

take the top places. The highest figure being that of the bird, the conclusion that the formative metabolism of the pectoral muscle of a bird is greater than that of the limb muscle of a mammal can be drawn.

The contractile metabolism of a muscle is dependent on its carbohydrate content. The carbohydrate percentages when taken into account, a higher contractile metabolism is indicated only in the bird, the figures for other animals being more or less near each other. If the combined weight of carbohydrates and fats is taken together, however, the figures appear more illuminating in accordance with our conventional evolutionary gradation. Whether the fats present in the muscle as a whole or at least some portions are readily convertible into carbohydrates to replenish the carbohydrate drain is not known.

The figures for fats taken separately show an increase from fish to frog, from frog to lizard, and from lizard to bird and mammal.

The ash content of the muscle shows the least variation. The percentages seem more or less the same for all groups.

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Name of the Candidate	Title of Thesis	Teacher	Place of Research
M.Sc.			
<i>Botany</i>			
Gadgil, G. H.	A Contribution to the Study of Sporogenesis in <i>Nephrolepis Exaltata</i> Schott and other Papers	Professor J. J. Asaria and Dr. T. S. Mahabale	E. C.
<i>Zoology</i>			
Nair, K. K.	A Comparative Account of the Flight Muscles of Some Representative Types of Bombay Birds with Notes on the Significance of their Variation	Dr. C. J. Grew	W.
<i>Microbiology</i>			
Sethia, K. E. (Miss)	Some Aspects of the Microbial Sterilization of Milk and Milk Fats	Professor J. V. Bhat	St. X.
<i>Agriculture</i>			
Deo, J. P. R.	Inheritance of Some Characters in Rice	Dr. B. S. Kadam	C. Ag
Ph.D.			
<i>Microbiology</i>			
Chav, R. V.	Buffalo Milk and its Preservation in Various Forms as 'Evaporated,' 'Separated' and 'Whole' Milk	Professor N. V. Joshi	E. C.
Joshi, S. G.	Soil Fertility and its Relationship with Bacterial Numbers and Biochemical Activities thereof in the Soil	Professor N. V. Joshi	E. C.
<i>Agriculture</i>			
Bhale, V. P.	Studies in Fusarium Wilt of <i>Lathyrus sativus</i> L.	Dr. B. N. Uppal	C. Ag
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KING SŪDRAKA

An Historical Study

(Continued from Page 21 of the July 1947 Issue)

BY DR. B. A. SALETORÉ,

Professor of History and Economics, Gujarat College, Ahmedabad

II. (E) MISCELLANEOUS DETAILS

UNDER this heading we shall discuss some details selected at random which will only add to the cumulative evidence we have hitherto adduced in support of our contention that the author of the *Mk.* was undoubtedly a monarch who belonged to the Deccan. First let us note the simple words *śreṣṭhīn* used in the *Mk.* Cāruḍatta is said to have lived in the Mayor's Place (*śreṣṭhī-catvare*) (Act II). In the history of the Deccan, as is proved by numerous records ranging over many centuries, a merchant was called merely a *vaṇija*, while a merchant-prince or a mayor was called a *śreṣṭhīn*. The history of the Deccan abounds in examples of numerous merchant-princes, who belonged to the Baṇaju or the Vira Baṇaṇju community, although occasionally we have merchants also of the Brahman community, who rose to great prominence.

Then comes the reference to tanks. In an exquisite metaphor, Vasantaseanā says to the Shampooer that virtue and fortune never go together. It is in tanks (*taḍāgeṣu*) where water is not drinkable that we find plenty of water (Act II). The southern regions are more famous for their tanks than the northern parts of India. One of the earliest examples of a tank constructed under royal orders is that at Tālguṇḍa (Sanskrit Sthānkundūr), which was built at the instance of the Kadamba king Kākustha in the fourth century A.D.⁶³ From that time onwards to the eighteenth century, the construction of tanks for irrigational purposes was a special feature of the civic life of the southern people.

The wicked Samsthānaka has, as we have seen in an earlier context, referred to the gourd of which the stock has been besmeared with cowdung (Act I). Making due allowance for the fact that this character is an expert in the use of malapropism, we may observe that the custom of besmearing the stock of a gourd (*karkārūka*) with lime, and not, as Samsthānaka relates, with cowdung, is typically true of the south and the west, where gourds and pumpkins of all kinds are ripened in this manner.

There is a direct reference to the southern habitat of the author of the *Mk.* in two contexts where the Nandanavana (Garden of the Nandas) is mentioned (Act IV). The Nandas are reputed to have ruled over the province called Kuntala which comprised the entire

⁶³ Rice, *My. & Coorg*, p. 179.

western Deccan and the north of Mysore.⁶⁴ In some of the most typical of the folksongs of the people of Tuluva, who form an ancient and interesting section of the Dravidians, there is a continual reference to the Garden of Nanda, which obviously is reminiscent of the good old days, when the ancient Nandas had ruled over the Kuntala province.⁶⁵

The mention of the village assembly (*grāma-samūha*) (Act V) is another proof, although not so conclusive, we confess, of the southern origin of the author of the *Mk.* No doubt, village assemblies existed in northern India; but if epigraphic evidence extending from about the sixth to the eighteenth century is to be relied upon, the village assemblies of southern India and of the Deccan, were most conspicuous by their varied civic, and sometimes political, activities.

Two more details suggest the southern nature of the author of the drama. They refer to the musical instruments *vinā* and flute, and to the peacocks. The *vinā* is praised twice (Act III & IV), and the flute with seven holes is mentioned in Act V. These, especially, the *vinā*, are southern instruments, whatever their occasional use might have been in other parts of India. The V. Act opens with a charming realistic touch of the southern regions, in the soliloquy of Cārudatta, who says that untimely clouds are rising overhead, which regarded by the domestic peacocks with plumes raised high and avoided by the flamingoes, who wish to go and who are, therefore, distracted, block the sky and the pining lovers' hearts simultaneously. We confess that this beautiful description might with equal truth be made applicable to any region of India, where peacocks abound; but all the same we may observe that it is more appropriate to the Deccan, and especially to the western districts, where one may still see the beauty of the peacock-dance during the early monsoon period.

II. (F) ŚUDRAKA AND CARUDATTA IN SOUTHERN HISTORY

So that the discussion on the southern habitat of king Śūdraka might be complete, we may give here the wide popularity which both that monarch and Cārudatta enjoyed in the history of the Deccan. We have already related in an earlier context that it is an error to suppose that the name Śūdraka is quaint, and that it was not assumed normally by kings. Here it might be objected that Bāṇa's character king Śūdraka (*Kādambari*)⁶⁶ may be taken to mean that there was a figure long prior to the subject of this paper. We admit that, while there is nothing to prevent the existence of an earlier Śūdraka, about whom, however, we know nothing, the mention of a king called Śūdraka by Bāṇa cannot be taken to mean that the person of that name, whom we have identified with king Śivamāra, did not belong to the Deccan. On the other hand, we think that Bāṇa's character may be taken to be the nearest contemporary of the author of the *Mk.* When we remember that Bāṇa lived also in the seventh century, we have only

⁶⁴ Rice, *My. & Coorg*, p. 3.

⁶⁵ I have quite a number of these folksongs in their original which await publication. A few have already been published in the *Indian Antiquary* LVI, pp. 13-17, 74-78; LVII, pp. 21-22. They have also been utilized in my *Ancient Karnataka*, Vol. I, *History of Tuluva*.

⁶⁶ Bāṇa, *Kādambari*, Purv. 25-26, pp. 109, 295 (Calcutta ed.).

to realize the truth of the praise given to Śivamāra in one of the epigraphs mentioned above, namely that his eulogy was sung by the Kin-naras on the Meru, Kailāsa, and the Vindhayas, in order to appreciate the fact that even during his own lifetime, the fame of king Śūdraka might have spread to the north, where the great author of the *Kādambari* took it up to give it further immortality. Indeed that in the seventh century the fame of Śūdraka had spread far and wide to the north as well as to the south is proved by epigraphic evidence which relates to the district of Tuluva or modern South Kanara. These epigraphs are written in Kannaḍa characters and language of the seventh century. One of the soldiers who died fighting in Tuluva in the second half of the seventh century, was Nāgamma of the Kayva-vamśa. He was known also as Śūdraka. This was in the reign of the Ālpua king Raṇasāgara.⁶⁷ In about A.D. 1088 we have one of the rulers of Tuluva called Udayāditya Pāṇḍya called a *Raṇaranga Śūdraka*.⁶⁸ Not only warriors and kings but books were also called by the name Śūdraka. Thus we have a work called *Śūdraka* written in Kannaḍa, and attributed to the poet Guṇavarma I, who lived in about A.D. 900.⁶⁹ But the kings were more often known as Śūdrakas in battle. This is evident from the history of the Deccan. The Hoysala king Vīra Ballāla II (A.D. 1173-1220) is compared in a record dated A.D. 1173, to a Śūdraka in battle (*raṇaraṅgaṇa Śūdrakam*).⁷⁰ In A.D. 1172 under the same Hoysala king, his Minister, who was also the Accountant-General (*śrī-karṇampradhānam*), by name Ācirāja, is given a long string of titles in which we have the following:—That Ācirāja was a Śūdraka in battle, and that he was equal in virtue to Dadici, Bali, Gutta, and Cārudatta.⁷¹ The same praise in regard to the same General is repeated in a record dated A.D. 1175.⁷²

The association of Śūdraka with Cārudatta in the above records was not fortuitous. Cārudatta seems to have been as much a native of the Deccan as Śūdraka himself. This explains the wide celebrity to which Cārudatta attained in the history of the Deccan. That Cārudatta's liberality had passed into history is proved by a record dated A.D. 1094 in which the Hoysala king Ereyanga (A.D. 1063-1095) is praised thus:—Who is equal to Ereyanga Deva? Double of Dadici-muni, tenfold of Gutta, a hundredfold of Cārudatta, a thousandfold of the son of Ravi (Karna), in all manner of bounty was the king Ereyanga.⁷³ But much more than monarchs merchants were compared to Cārudatta in their bounty. Thus in about A.D. 1020 a great merchant named Jekki Setṭi, in the reign of the famous Hoysala king Viṣṇuvardhana Deva, is compared in effort to Cārudatta (*sāhasam-Cārudattam*).⁷⁴ One of the many encomiums bestowed on the same Hoysala monarch Viṣṇuvardhana (circa A.D. 1110-1141), as given in a record dated A.D. 1131, is that he was a modern Cārudatta (*abhinava-Cārudatta*).⁷⁵ But king Viṣṇuvardhana's son Nṛsiṃha is des-

⁶⁷ & ⁶⁸ Saletore, *Ancient Karnataka*, Vol. I: *History of Tuluva*, pp. 85, 100, 171.

⁶⁹ Narasimhacharya, *Kannaḍa Karicharite*, I, pp. 24-25.

⁷⁰ *M.A.R. for 1926*, pp. 59-60.

⁷¹ *Ep. Car.* VI. Kd. 66, text p. 42.

⁷² *Ibid.*, Kd. 53, text p. 36.

⁷³ *Ibid.*, V, Ch. 148.

⁷⁴ *Ibid.*, IV. Ng. 103.

⁷⁵ *Ibid.*, II. No. 143,

cribed in a record dated A.D. 1199 to be merely Cārudatta.⁷⁶ The merchant-princes were more often compared to Cārudatta. Thus in A.D. 1149, a liberal merchant called Mānika Śeṭṭi is praised thus :— “Who can describe the spotless character of Mānika Śeṭṭi, who was bent on doing good to others (*para-hita-caritam*), whose only jewel was truth (*satyābharanam*), who was equal to Kubera, Lord of Wealth, and to Cārudatta (*Dhanada-Cārudatta-samānam?*)”⁷⁷ Another merchant-prince of unrivalled liberality was Bācaya or Bāci, whose descent is stated in a record dated A.D. 1151. This epigraph compares him to Bharata, Gutta, Śibi, Khecara, Bali, and Cārudatta.⁷⁸ General Kāntimayya is described in a record dated A.D. 1164 as equal to Gutta and Cārudatta, because he had erected a Śiva temple.⁷⁹

We cannot do better to prove that Cārudatta was essentially a southern name than to show that it was assumed by lay men and priests alike. The first part of the name *Cāru* (or *Cāra*) was borne by women and was also given to villages in the history of western India. The first part of the name is what concerns us here, since the second part *datta* was variable. Thus we have the names Cāraṇa (or Cāraṇṇa) Heggade, Cārukīrti Nāgappa, among men; Cāravve and Cāravakable among women; Cārukīrti Paṇḍita Ācārya and Cārumūrti Maheśvara among the Jaina and Lingāyat priests respectively; Cāruponnera among the Pallava princes; and Cāraunballi among villages. This list is by no means exhaustive.⁸⁰

III. SOME PROBLEMS ANALYSED

(A) The problem of the dual authorship, of the use of Prākṛit, and of the plot of the *Mk*.

The identification of king Śūdraka with king Śivamāra I of the Ganga royal house, which we have postulated in the preceding pages, heightens the interest of the question of the authorship of the drama, and brings into prominence another problem allied to it, and which is equally complicated. Scholars till now, with few exceptions, have come to recognize that the *Mk*. was the work of one man, although they admit of interpolations in the text of the drama. This is not surprising when we find that critics of the *Mk*. have studied the drama only from the point of view of its literary excellence, and not, as we have done, in its historical setting. Literary critics are aware of a defect in the continuity of the plot of the drama; but in most instances they have attempted to justify it on purely literary grounds. But we have valid reasons for maintaining that the drama was not the work of one man but the product of two master minds.

Our assertion that the drama was written by two authors is based on the following considerations :—

Firstly, the explicit statement in the prologue that the author was dead. While describing the attainments of king Śūdraka, we are told that after attaining one hundred years and ten days, he died (*āyuh*

⁷⁶ *Ibid*, IV. Ng. 47.

⁷⁷ *M.A.R. for 1928*, pp. 78, 79.

⁷⁸ *Ep. Car.* XII. Tm. 9, text.

⁷⁹ *Ibid*, IV. Ng. 30, text.

⁸⁰ Since the sources are too many, the reader is referred to the volumes of the *Ep. Car.* and the *M.A.R.*

śatābdam-daśāḍinasahitam Śudrako'agnim praviṣṭha). The literal meaning of the last two words, no doubt, means *entered the fire*. But this phrase has to be understood in the ordinary sense of *died*. If the author died on his attaining the 100th year, then, as Keith rightly observes, "no one can believe that he foresaw his death-day so precisely, or that the ceremony referred to is that performed on becoming an ascetic, or even that the prologue was added after his death."⁸¹ While agreeing with the major conclusion of Keith that it is absurd to imagine that an author could write a drama, foresee his death, and note it as well, we may at the same time dissent from the view that the prologue could not have been written after the death of king Śūdraka. We do not assume here that an author does not mention his name in his work written during his life time. Thus, king Śātakarṇi refers to himself as living in his work *Gāthāsaptasatī* (5, 67). But the explicit reference to the king Śūdraka's having committed himself to flames, precludes any idea of that monarch's having written the prologue; but it does not prevent us from maintaining that the first part of the drama was written by him.

The fact that king Śūdraka was not alive when the prologue was written is further proved by the use of the word *kila* ("so it is said," "so they say") twice in the prologue. Once it is while dealing with that king—*kṣitipālāḥ kila Śūdrakāḥ babhūvaḥ*. Then, again, while dealing with Cārudatta—*Avantipurāyāṁ dīpja sārthavaḥ yuva daridrāḥ kila Cārudattaḥ*. Therefore, both king Śūdraka and Cārudatta, the hero of the drama, were persons who belonged to the past, and who were known to history and tradition. Hence, since king Śūdraka is explicitly stated in the prologue to have died, we are compelled to arrive at the conclusion that the second part of the drama could not have been written by him.⁸²

If king Śūdraka could not have written the whole of the drama, and perhaps not even the prologue, we have to find out where his contribution ends and that of his successor begins. To answer this question we have to examine the whole plot of the drama. In Act II we have Darduraka saying the following aside:—"I have made an enemy of Māthura, the Chief Keeper of the Gambling Houses. It will not do to stay here now. And, besides, my friend Śarvilaka has told me that according to a prophecy a cowherd boy named Āryaka is going to be king. Everybody in my condition of life is joining his faction. So I had better go to him." This is excellent, no doubt, from the point of view of literary *dénouement*, but inexplicable from the historical standpoint, except on the basis of the following considerations. It is possible that the passage beginning with "And, besides," and ending with "go to him," was inserted afterwards by the second author of the drama in order to justify his continuation of the drama, which would be taken up by him in the IV Act in such a beautiful manner as not to create the impression that the drama was ever written by two authors!

⁸¹ Keith, *Skt. Drama*, p. 130.

⁸² This difficulty was foreseen by R. W. Fraser many years ago, when he wrote the following:—"Many of the scenes are undoubtedly filled with all the exuberance and artificiality of an Eastern poet's imagination, which makes it rash to assert that the whole play is the work of one hand." (Fraser, *A Literary History of India*, p. 283. London, 1898). But Fraser has no arguments excepting the one given above, in support of his assertion. I daresay literary critics could give further proof in support of my doubt about the double authorship of the *MK.*, by examining the setting of the various scenes and of the stage in the first and second parts of the drama.

But what strikes a student of history in regard to the continuity of the historical action is the suddenness with which the political plot is ushered in Act IV. When Śarvilaka gets into the cart with Madanikā and starts to go, a voice behind the scene proclaims the following:—"Hullo! Listen! Listen! The District Magistrate has issued the following Order—That there is a prophecy that truly the cowherd boy Āryaka will become king! Feeling alarmed at this prophecy becoming true, king Pālaka has removed Āryaka from his hamlet and imprisoned him in a terrible dungeon. Therefore, all ye, be diligent, each one of you, in his post!" Making all allowance for the literary merits this announcement might have in the drama, it cannot be denied that it introduces an underplot that requires an explanation. The change in dynasty that is suggested in the above passage is confirmed, for instance, in a later context when General Viraka summons Jaya, Jayamāṇa, Candanāka, Mangala, Puṣpabhadra, and others to be on their guard, since Āryaka, who had been confined, had escaped from prison, thereby breaking both the chains that fettered him and the king's heart. Candanaka says to Viraka—"Be quick so that the king's royal power will not be able to effect a change of dynasty." (Act VI).

How important the above passages are in our estimate of the author of the second half of the *Mk.* will be evident presently. In the meanwhile, we may note that in the main plot which is superbly simple, is introduced an underplot of considerable political significance. The author, who wrote the drama from about the middle of the IV Act, evidently was in some manner connected with the political plot. Further, the exquisite way in which the underplot is woven in the main action suggests that its author was an expert in the theory and practice of drama. From the many striking similes one meets with in the drama from the IV Act onwards, it is evident that their author was also a great poet. And from the many references to the artistic pictures painted on the walls of the palatial residence of Vasantasenā, and the many equally artistic things that were visible in it (Act IV), it is likewise also clear that the dramatist was well-versed in fine arts. These considerations must be taken together with the next one relating to the use of Prākṛit words. Although we confess that the use of Prākṛit was, as the *Sūtra-dhāra* rightly says, quite in keeping with the convention of the stage, yet it is permissible to assume that, from the middle of the IV Act, when the underplot is introduced, the use of Prakrit is, on the whole, more plentiful than in the first three acts of the drama. This makes us presume that the author of the second part of the play was a great master of Prākṛit. Sixthly, the splendid scene of the court of justice as given in Act IX, which for its realistic thoroughness is perhaps unique in the whole range of Sanskrit literature, compels us to suppose that the author, who wrote it, was himself a person who was well acquainted with the rules of justice and who abided by them. And, finally, the fact that in the same Act (IX) there is a good deal of logic, and that in two of the previous Acts (IV and V), the author has a tendency to make his characters lapse into a philosophical mood, suggests that he was likewise versed in logic and philosophy.

Now we have to see whether there was any one who satisfied the seven conditions mentioned above, and who could have finished the *Mk.* in the manner begun by king Śūdraka. It is more than a mere coincidence that there was in the same royal family to which king Śivamāra I

belonged, a ruler who conclusively satisfies all the seven conditions which we have just now enumerated. Before we relate them in detail, it is worth while to follow the course of political events in the Ganga kingdom soon after the death of king Śivamāra I. The history of the Gangas, which is by no means free from chronological and historical difficulties, tells us that, as we have pointed out elsewhere,⁸³ king Śrīvikrama (whose dates are uncertain), had two sons—the elder of whom was called Bhūvikrama, and the younger, Śivamāra I. King Bhūvikrama, as narrated above, was a great warrior, who defeated the Pallava king Narasimhapotavarman in the battle of Viḷinda, as a result of which the entire Pallava dominions passed under the suzerainty of the Gangas. The last year of king Bhūvikrama was A. D. 670. He changed his capital to Mankunda in the Chennapaṭṇa tāluka of the Mysore State.

His younger brother called Śivamāra I followed him. We have already said that he lived for a complete hundred years. His reign ended in 725. His son Durnvīta Eṇeyanga, we may be permitted to repeat, was placed as Governor over the districts of Torenād, Kongalnād, and Male. It must be confessed that the exact relationship between Śivamāra I and Durnvīta Eṇeyanga is nowhere explicitly stated in the epigraphs. And in the Ganga genealogical lists Eṇeyanga's name does not appear. This fact is significant for our purpose. We may proceed with our narrative of the events of king Śivamāra I's reign which witnessed, as far as the internal affairs of the Ganga kingdom were concerned, stabilization of administration mixed with political anxiety from abroad. The former is evident from the many stone inscriptions which replaced the copper-plate grants that were till that time common; and the latter is suggested by the activities of the enemies of the Gangas. For in this century, when the Gangas were busy conquering the southern and eastern territories, they were attacked in the north-western parts of their empire by their enemies. The Kadambas and the Western Cālukyas of Bādāmi challenged the claims of the Gangas to political supremacy. Of these the Cālukyas were more difficult to deal with for the Gangas. First king Kīrtivarma (A. D. 560-597), then the famous Pulikeśin II (A. D. 609-642), and, finally, the latter's grandson Vinayāditya (A. D. 680-696)—these Western Cālukya monarchs brought the Gangas under their control, although they always treated them with special consideration, because of the great antiquity of the latter.

For a brief space of about eighty years, the Ganga kingdom enjoyed prosperity and a reputation for wealth which secured for it the name of *Śrīrājya* or the "Fortunate Kingdom." It is here that we have to explain the significance of some of the facts mentioned above. For instance, we have said that king Śivamāra I's reign ended in 725; that prince Durnvīta Eṇeyanga may have succeeded him; but that this prince's name is not met with in the genealogical lists of the Gangas. Indeed, in all the Ganga records, the royal descent is traced from Śivamāra I direct to his grandson Śrīpuruṣa II.⁸⁴ The first regnal year of the latter is 726, and he reigned from 726 till about 797.⁸⁵ It was in his reign

⁸³ I have discussed this in my paper styled *The Bana, the Gangas, the Kadambas, and Other Feudatory Families*, contributed to vol. III of the series to be published by the Indian History Congress.

⁸⁴ Cf. *Ep. Car.* IV. Gd. 47.

⁸⁵ *M.A.R. for 1933*, pp. 237-238. But it is a debatable point whether Śrīpuruṣa lived till A. D. 801. See *M.A.R. for 1933*, pp. 237-238.

that, as narrated above, the entire Ganga kingdom came to be called *Śrīrājya*.

We shall concern ourselves for a while with this ruler Śrīpuruṣa II, before passing on to the reign of his successor. Two facts may be noted in connection with king Śrīpuruṣa II. The first is that there was an interval of about one year after the death of king Śivamāra I in 725 and the accession of king Śrīpuruṣa II. This blank in the royal succession is not commented upon in the Ganga records. We know also that in all probability king Śivamāra I's son was Durvinīta Ereyanga; and that in the reign of his father, this prince, obviously in accordance with the ancient practice of the land, was placed as a governor over certain districts. We know further that Śivamāra I's grandson, the future Śrīpuruṣa II, was likewise placed as a governor over the Kerekundanād 300, the Elenagarnād 70, the Avaneyanād 30, and the Ponkunda 12 districts. The second fact to be noted is that king Śrīpuruṣa II changed his royal residence from Mankunda to Mānyapura (Maṇṇe in the Nelamangala tāluka). Taking these facts into consideration, the question arises—Was there any conflict between Durvinīta Ereyanga and a rival of that prince, who might have aspired to the throne? Historians till now have not commented upon this detail, but in view of the soundness of the identification of the author of the first part of the *Mk.* with king Śivamāra I, we are, we believe, justified in assuming that there was a conflict between Ereyanga and an unknown rival of his, which resulted in the success of Ereyanga's son and successor Śrīpuruṣa II. No doubt we could likewise assume that Ereyanga died as a governor. But this latter assumption would not only violate the identification we have proposed in this paper, but also the statements which are available in the epigraphs relating to Ereyanga's (son and) successor Śrīpuruṣa II.

These statements in records, ranging from the middle of the seventh century to the end of the ninth century, afford ample ground for affirming that Śrīpuruṣa II's accession was by no means a peaceful one. This is evident from the qualifying phrases "having obtained a good kingdom" (*śaurājyam upetya*), and "ever victorious is the king," which are used in connection with Śrīpuruṣa II. Thus in a record of the same king, dated A. D. 749, we are informed that "having obtained a good kingdom," "ever victorious is the Rāja Śrīpuruṣa."⁸⁶ In another of his public grants, dated A. D. 776, we have the following:—"having obtained a good kingdom, a king of superior qualities among all the kingdoms, ever victorious is the Rāja Śrīpuruṣa."⁸⁷ The same phrase is given to him in a record dated A. D. 797 and in another one, dated in about A. D. 900.⁸⁸ If anything could be deduced from this special phrase used in connection with king Śrīpuruṣa II, and from the fact of his having changed his royal residence to Mānyapura, it is the following—That he had to struggle against an unknown rival, obviously of the main or collateral line of the Ganga house, before he came to the throne; that Śrīpuruṣa II won against him, thus preserving the royal succession in the main line; and that as a political measure he changed his capital to Mānyapura, from where he could rule in peace. It is for this reason that Mānyapura is called "the victorious camp" in records.⁸⁹ We are,

⁸⁶ *Ep. Car.* IV. Mg. 36.

⁸⁷ *Ibid.* Ng. 85.

⁸⁸ *Ibid.* IX. Nl. 60; *M.A.R. for 1919*, p. 28.

⁸⁹ *Ep. Car.* IV. Ng. 85, *op. cit.*

therefore, justified in affirming that on the death of his grandfather Śivamāra I, whom we have identified with king Śūdraka, there was a civil war in the Ganga kingdom which ended in a victory to the grandson of that ruler. The fact that Śivmāra I's son Ereyanga is not mentioned in any inscription discovered hitherto,⁸⁰ suggests that prince was worsted in the struggle but that his (son and) successor Śrīpuruṣa II came out victorious. The successor of Śrīpuruṣa II was his son Śivamāra II, with whom we are now directly concerned.

Let us now revert to the second part of our main thesis, *viz.*, the identification of the second author of the *Mk.*, who continued the work which king Śūdraka had either left incomplete or had deliberately brought to an end. We said above that this second author must have been in some manner acquainted with the political plot which has been so dexterously interwoven in the main action of the drama. When we realize that king Śrīpuruṣa II, who, we presume, was himself involved in the plot, was followed by his son Śivamāra II, we shall find that we have got over a great difficulty in the question of the identification of the second author of the *Mk.* It was during Śivamāra II's father Śrīpuruṣa II's reign that a struggle between the rightful claimant (Śrīpuruṣa II's father Ereyanga) and some unknown person had taken place; that an attempt had been made to supplant the old dynasty by a new one; and that in the end Śrīpuruṣa II succeeded in becoming king. It is precisely these facts which are reflected in the two passages relating to the plot and the change in the dynasty, which we have cited above. The fact that king Pālaka in the drama, has not been endowed with any outstanding quality or even a generous epithet by the author, suggests that king Pālaka represents the unknown rival of king Śrīpuruṣa II's father Ereyanga, who was worsted in the struggle, leaving to his son the credit of defeating the pretender and of restoring the glory of the main line of the Ganga royal house. In any case, Śrīpuruṣa II's son Śivamāra II was evidently an eyewitness to the above events; and this explains why he satisfies the first of the seven conditions we have enumerated above. We might unequivocally assert that king Śivamāra II was himself the author, who completed the drama which had been left either incomplete by king Śūdraka, Śivamāra I, or which the latter had deliberately written in brief.

We have now to see whether king Śivamāra II (A. D. 797—815), satisfies the remaining conditions enumerated above, *viz.*, that he was an expert in the theory and practice of drama; that he was a great poet; that he knew the fine arts; that he was a master of Prākṛit; that he ruled according to justice (*dharma*); and that he knew logic and philosophy. Before we proceed further we may observe that his reign was full of mingled troubles. He lived in a world of endless calamities which, according to an inscription dated A. D. 903, were like matted pairs of top-knots or twisted top-knots.⁹¹ We shall refer to the evidence of this epigraph presently. Here we may note that Śivamāra II was first imprisoned by the Rāṣṭrakūṭa king Dhārāvāṣa, released by the latter's younger brother Govinda, imprisoned again by Govinda, and finally released and crowned by king Govinda himself! Never in the entire history of

⁸⁰ It is not unusual in historical records to omit the names of rulers who either failed against the rivals to the throne, or who were compelled to abdicate by the people.

⁹¹ *Ep. Car.* X. Kl. 90,

the Deccan had misfortune so mercilessly dogged the footsteps of a monarch as in the case of the magnanimous Śivamāra II ! But it never damped his spirits, and in no way lessened his dignity. In the direst period of his political vicissitudes, Śivamāra II preserved his wonderful equanimity. This special feature of his noble character will have to be borne in mind when we shall presently cite the evidence of epigraphs in support of our contention that he was the author who continued and perfected the drama which had been begun by king Śūdraka, Śivamāra I.

One of the earliest epigraphs which gives us almost all the details we need for our identification is the big copper plate grant hailing from the royal city of Maṇṇe (Māṇyapura) itself. In this Maṇṇe copper plate grant dated A. D. 797, which we presume to be the earliest year when Śivamāra II's eldest son Mārasimha is represented, according to the time-honoured practice of the rulers of Karnaṭaka, as a *yuvārāja* in charge of the *akhaṇḍa* (united) Gangamaṇḍala, we have the following, among other details, about Śivamāra II :— "... desirous of benefiting others without seeking any benefit for himself; having by his administration of justice rooted out the evil practice of the Kali age; his skill in the practice of politics putting to shame Brihaspati; his character like a stone pillar for the support of *dharma* destroyed by the myriad deceits of the hosts of evil kings; the world of the twice-born gratified with his constant bestowal of gifts; whose donations by absence of divided desires and by benefiting all the world, exceeded the pouring forth of water by the regent elephants. Moreover, placed in a world of endless calamities like twisted top-knots, supporter of fine arts; friend of the learned; able in protecting; ... famous as a poet; skilled in poetry; having seen to the farthest shore of the Phanisuta-mata (Patañjala system) difficult to understand; of firm intellect which was a touchstone to the science of logic; his insight into the essence of the management of elephants (*sāmañja-tantra*) lowered the pride of the learned; of profound knowledge in expounding the system of the great *yati* born from the mouth of the female elephant (*hastini-vakrodbhava-yati-pravara-mata*)⁹²; author of a treatise on his own system of the treatment of elephants (*gajamata*); of no mean intellect; author of a work called *Setubandha*; gratifier of the circle of the learned; skilled in all matters connected with the drama, its combinations and branches."⁹³

Another record of the same *yuvārāja* Mārasimha, dated two years later (A. D. 799), confirms almost all the details about king Śivamāra II which are mentioned in the Maṇṇe copper-plate grant. This record called the Ālūr grant affirms the following :—"His (Śrīpuruṣa II's) son... desirous only of benefiting others without seeking any benefit for himself; having by his administration of justice rooted out the evil practices of the Kali age; so skilful in the application of his own political theories as to bring shame to Brihaspati; possessed of character like a stone-pillar for the support of *dharma* destroyed by the myriad deceits of the hosts of evil kings; having gratified the world of the twice-born with his constant bestowal of gifts; he whose donations free from motives and beneficial to all the world exceeded the pouring forth of water by the regent elephants. Moreover, by a band of idiots was he thrown in a place of end-

⁹² The reference, as Rice correctly maintains, is to *Pālakāpyam* of Pālakāpya, or Karenubha. *My. & Coorg*, p. 199,

⁹³ *Ep. Car.* IX, Nl, 60,

less captivity; he was the supporter of fine arts, engaged in doing good to the learned, the true birth-place of pure qualities; a leader of kings; a poet thus was he praised by experts in poetical composition. A distinguished sailor able to reach the other shore of the unfordable ocean of Pāṇini's grammar; possessed of firm intellect which is a touch-stone to test the science of logic; possessed of a thorough knowledge of elephant-training, with which he put down the pride of the learned in that art; endowed with profound knowledge in expounding the system of the great ascetic born from the mouth of a female elephant; an expert in discussing the new enquiries into many subjects proposed by the learned; perfect in the science of the management of horses; a sun in causing to unfold the lotus garden the science of archery; possessed of intellect sharpened on account of his own creation of a new treatise on the various uses of the tusks of elephants; the author of a work called *Setubandha*; gratifier of the learned; an expert in the application of the principles of dramatic composition of various kinds."⁹⁴

That the praise given to king Śivamāra II in the above contemporary records was no conventional bombast is proved when we note that he is described in identical terms in a later record dated about A. D. 903, of the reign of one of his successors called Rājamalla II. In this incomplete copper-plate grant hailing from Narsāpura, we have the following:— "....Moreover, brought into this world mingled with troubles, like matted pairs of top-knots, supporter of fine arts, beloved by the learned, devoted to policy, a birth-place of pure qualities,....esteemed as a poet, skilled in poetry,....was Śivamāradeva."⁹⁵

So late as A. D. 1077, when the Gangas had practically ceased to play their noble part in the politics of the Deccan, we have a long and splendid account of this ruler in a stone inscription discovered in the Jaina temple called Pañcabasti at Humccha, Nagar tāluka, Mysore State. It relates the following:— "His (*i.e.*, Bhūvikrama's) younger brother was the king Kāma (or Nṛipa Kāma), who having given an elephant to a supplicant, obtained the name Cāgi. . . . Then known as Viramārttaṇḍadeva, was his (Śrīpuruṣa II's) son Śivamāra Deva, who bore the second name Saigoṭṭa, and wrote the Gajasāstra called *Śivamāra-mata*. Moreover, what can be said of the king Śivamāra's poetical genius? If in the world the *Gajāṣṭaka* was imparted to a dumb man, in place of being dumb he gained the power to speak!"⁹⁶

Before we proceed to summarize the evidence of the above contemporary and later records, which describe the intellectual attainments of king Śivamāra II, it is worthwhile to examine the two contemporary documents, *viz.*, the Maṇṇe plates and the Ālūr plates issued under the command of the *yuvārāja* Mārasimha, in order to see whether the eulogy bestowed on Mārasimha's father Śivamāra II could be accepted as historically correct. They may be examined from the following seven points of view:—the find-spots; the name, designation, and duties of the donor; the dates of the gifts; the donees, their names, attainments, and religion; the name, nature and location of the gift; the witnesses; and the names and designation of the scribes who engraved the two documents.

⁹⁴ *M.A.R. for 1924*, pp. 73-74, 77.

⁹⁵ *Ep. Car. X.* Kl. 90.

⁹⁶ *Ibid.*, VIII, Nr. 35.

We shall take the find-spots. The Maṇṇe plates were found in the possession of a person called Sālvanta Rudrappa in the village of Maṇṇe itself in the Nelamangala tāluka of the Mysore State; while the Ālūr plates were found in the possession of a man called Avalakoṇḍappa in the village of Hospet in the Jangamakōṭe hobli. (The first record was discovered by Lewis Rice prior to 1905, when *Epigraphia Carnatica*, Volume IX was written; while the second document was discovered by Shama Sastri in 1924 when he wrote his *Report of the Mysore Archaeological Department*). As regards the donor, he was the same Ganga prince Mārasimha; but his duties are different in the two documents. In the Maṇṇe plates, he is given many titles among which is the following—“By him, having the other name of Lokatrinetra, having the rank of *yuvārāja*, etc., etc., named Mārasimha, (who) was ruling the *akṣaṇḍa* (united) Gangamaṇḍala.” In the Ālūr plates, we have an equally long list of titles, among which may be noted the following:—He was Lokatrinetra by name, installed on the seat of *yuvārāja*, etc., etc. The next point in regard to the date will clarify a further detail about the *yuvārāja*, Mārasimha. In the Maṇṇe plates, the date is given thus—“The Śaka year of this—three months after the seven hundred and nineteenth year, on the 5th of the bright fortnight of Āśāḍha, in Uttara-Bhādrapada, Monday,” (= A. D. 797, June, Sunday the 4th, the week-day not corresponding).⁹⁷ The date of the Ālūr plate is given thus—“... there having elapsed seven hundred and twenty years of the Śaka era, there having also expired three years of his prosperous administration (*ātmanah pravardhamāna-samvatsareṣu triṣu-samatiteṣu*), on Monday, the full moon day of the month of Śravaṇa with Dhaniṣṭha constellation on the occasion of a lunar eclipse” (= A. D. 798, April the 1st Wednesday, when there was a Lunar eclipse, and when the nakṣatra was Dhaniṣṭha) when there was of course full moon.⁹⁸ The donees also are quite different. In the Maṇṇe plates, the donee was the exalted Jaina *guru* Śrīvijaya, who had caused to be made the Arhat Jaina temple in Mānyapura itself. Great praise is bestowed on this Jaina *guru*; and the Jaina temple which he caused to be constructed is said to have been “lofty and immaculate.” While the donee of the gift recorded in the Ālūr plates was the pious and learned Brahman (descent and *gotra* stated) named Śrīdhara, the son of the learned Brahman Ponnera.

We come now to the fifth point—the names and location of the villages given as gifts. The Maṇṇe plates register the gift of Kīru-Vekkūru village (its boundaries given in detail); while the Ālūr plates record the gift of the village of Koṭṭemba in the country of Mānya (its boundaries also given in detail). We may also note in this connection that a supplementary gift of certain lands were given to another Jaina *guru* called Prabhācandra, which is registered in the Maṇṇe plates; while in the Ālūr plates, no supplementary gift is recorded. The witnesses to both the gifts recorded in the Maṇṇe plates and the Ālūr plates, were the people of the Ganga kingdom which was called the 96,000 Province—*asya dānasya-sākṣiṇaḥ Saṇṇavati-sahasra-viśaya-prakṛitayaḥ*. The official scribe, who engraved both the documents, was called Viśvakarmācārya; but in the Maṇṇe plates, which are about three years earlier than the Ālūr plates, he is given the following praise—“Viśvakarmācārya,

⁹⁷ Swamikannu *Indian Ephemeris*, I, pp. 196.

⁹⁸ Swamikannu, *ibid.*, I, p. 198. The week-day in this case was Wednesday and not Monday, as given in the record.

acquainted with all the arts, skilled in the art of painting," which praise is not found in the Ālūr plates. Therefore, since the Mañṇe plates were distinct from the Ālūr plates, although the donor of both was the same, and both were engraved by the same royal scribe, we may definitely accept them as historically correct.

With the above conclusion before us, we may proceed to summarize the evidence we have outlined above, in regard to the character, attainments, and works of king Śivamāra II, whom we have credited with the continuation and completion of the *Mk.*, which had been begun by king Sūdraka, Śivamāra I. The evidence of the above epigraphs may be divided under the following heads: the liberality, the nature of administration, the learning, the knowledge of fine arts, the greatness as a poet, the knowledge of logic, the mastery of the theory and practice of drama, and the literary works of king Śivamāra II.

That the ruler was an uncommonly liberal minded person, is evident from the statement that he was desirous of benefiting others without seeking any benefit for himself; and that his donations exceeded the pouring forth of water by the regent elephants. The nature of his administration was marked by justice; and his character was like a stone-pillar for the support of the *dharma*. His learning was remarkable: he was the friend of the learned; and he had mastered the grammar of Patañjali. He was the supporter of the fine arts. As a poet, he was famous, being skilled in poetry. Indeed, one of his works to be mentioned presently, seems to have been extraordinarily beautiful. As a dramatist, he was skilled in all matters relating to the theory and practice of drama. He was well-versed in logic. But his most abiding gifts were his works on elephants and on a subject, about which we shall mention in the next paragraph. He knew about the management of elephants (*sāmaja-tantra*); he was the author of a work on the treatment of elephants (*gajamata*), and of another work called *Śivamāramata*. A word about these two works may not be out of place. The latter work called *Śivamāramata* was in Kannaḍa,⁹⁹ while the former called *Gajāṣṭaka* was in Sanskrit. About the latter we have the interesting information that if it was imparted to a dumb man, it would enable him to speak.

If the above evidence is insufficient to prove king Śivamāra II's poetical genius, we may give a further example of a work by the same ruler, which is doubly important for our purpose. It establishes beyond doubt his ability as a poet; and it proves our contention made in the preceding pages that the second part of the *Mk.*, which seems to abound in Prakrit words, could have been written only by an author who was a master of Prākṛit. In both the Mañṇe plates and the Ālūr plates, we have the important statement that he composed a work called *Setubandha* (*viracita-Setubandha*, in the Ālūr plates; *virājita-Setubandha*, in the Mañṇe plates). This work was evidently no other than the Prākṛit work called *Setubandha* which till now was supposed to have been written by Kālidāsa. Macdonell wrote thus about this work:—"We may mention in conclusion, that there is also an epic in Prakrit which is attributed to Kālidāsa. This is *Setubandha*, *Building of the Bridge*, or *Rāvaṇa-vadha*, which relates the story of Rāma. It is supposed to have been composed by the poet to commemorate the building of a bridge of boats across

⁹⁹ Narasimhacharya, *Kavicharite*, I, p. 17.

the Vitastā (Jhelum) by king Pravarasena of Kashmir.¹⁰⁰ Without entering into a discussion of the historicity of king Pravarasena, who does not figure in the known genealogical lists of Kashmir,¹⁰¹ we may merely observe that for poetical beauty, this work seems to have been classed with the works of Kālidāsa. This alone explains why it was till now supposed to have been written by that great poet ! The importance of the identification of its author with king Śivamāra II, so far as we are concerned, lies in the fact that it proves beyond doubt that the ruler was a master of Prakrit ; and that, therefore, he could certainly have completed the second part of the *Mk.*, in which, we may be allowed to repeat, there seems to be a larger proportion of Prakrit words than in the earlier part which we maintain was written by king Śūdraka, Śivamāra I. We may incidentally add that it is more than a mere autobiographical reference which Śivamāra II makes to his own character—which he had tried to make as ideal as possible—and to his great work *Setubandha*, in the passage attributed to one of the Cāṇḍālas, wherein we have the following about Cārudatta's noble character:—"Stand out of the way, Gentlemen, out of the way ! Today is being taken out of the city one who was its goldless ornament, one who was a treasure of virtue, and a bridge that helped good men to cross over their difficulties." (Act X).

The literary attainments, poetical genius, mastery over the theory and practice of drama, and profound knowledge of elephant-lore which characterized Śivamāra II, were by no means accidental gifts. We have epigraphic proof to maintain that they were literary gifts inherent in the great Ganga royal family. One of their earliest kings called Mādhava II (circa A. D. 225-250), was the author of a commentary on Dattaka's aphorisms (erotics). The latter was a work called Vaiśeka. King Durvinita, another Ganga monarch, who ruled from A.D. 482 till 540, wrote a Kannaḍa commentary on the fifteen *sargas* of Bhāravi's *Kirātārjuneya*. With this literary genius imbedded in the Ganga royal mind, it is not surprising that Śivamāra I, otherwise known as Navakāma Śrīpuruṣa I, should have written the earlier part of the *Mk.*, excelled in the science of erotics, and also have written a work on elephants called *Kalpanāratnam*. Both the poetic faculty and the insight into the elephant-lore were transmitted to his grandson Śrīpuruṣa II, who wrote a work on elephants called *Gajaśāstra*. These two literary traits were further developed by Śrīpuruṣa II's son and successor Śivamāra II, as we have already noted above, and still further by a later Ganga ruler called Bhūtugendra (A. D. 938-953), who is said to have been the son of Kareaṇu (Pālakāpya) in the knowledge of the great science of elephants.¹⁰²

There is one detail which might be disposed of here. It is that which refers to the Kannaḍa language which has been mentioned often above. It may be argued that rulers of the Ganga house, who reigned in a land that was predominantly Kannaḍa in language and thought, could hardly have been the authors of a work which contains a

¹⁰⁰ Macdonell, *History of Sanskrit Lit.*, pp. 331-332.

¹⁰¹ See Ray, *DIINI*, I, pp. 105-183.

¹⁰² *M.A.R.* for 1920, pp. 46, 47, 48 ; *Ep. Car.* IV. Ng. 134 ; XII. Tm. 23 ; VI. Mg. 36 ; IX. Nl. 60 ; *M.A.R.* for 1925, pp. 87, 88 ; *Ep. Car.* VIII. Nr. 35. On Ganga chronology, the reader is referred to Rice, *My. & Coorg*, and to my paper on *The Banas, the Gangas, and the Kadambas* mentioned above.

very large percentage of Prākṛit words. That is to say, it may seem doubtful whether we have to refer the term Prākṛit, as has been understood by some scholars till now, only to these languages like Ardha-Māgadhi, Saurāṣeṇi, Mahārāṣṭri, and the like, or to others as well which have not been included under the general designation of Prākṛit. Here it is interesting to observe the opinion of authors, who lived in the tenth century A. D. One of them is the celebrated grammarian Nāgavarmma I (circa A. D. 990), the author of *Cochandhombudhi* and *Karnāṭaka-Kādambari*. The former is the standard work on prosody in the Kannada language. In it we have the interesting statement that from Sanskrit, Prakrit, Apabrahmṣa, and Pāisāci languages sprang up Drāviḍa, Āndhra, Karnāṭaka and all other *jāti* languages.¹⁰³ Without discussing this opinion of the great grammarian Nāgavarmma, we may merely observe that in the seventh and eighth centuries, it was universally accepted as an axiom in the Deccan that literary men should be well-versed in Sanskrit and Prākṛit languages. This explains why we have in the olden times quite a number of men of letters, who were proficient in both Sanskrit and Prākṛit languages. For our purpose we may note that the use of Prākṛit in the *Mk.* can hardly be adduced in support of the theory that the work was necessarily written in the first or second century A. D. Keith's comment in this connection may be borne in mind here. "Nor can anything be deduced from the plentiful exhibition of Prākṛit, which is not, to judge from Bhāsa, a sign of very early date; while the use of Mahārāṣṭri Prākṛit would be, if proved, conclusive that he (Sūdraka) is fairly late."¹⁰⁴

III. (B) THE PROBLEM OF THE DATE OF THE *Mk.*

After having established the identity of king Sūdraka with king Śivamāra I, and maintained that the drama was continued and completed by Śivamāra II, we may now fix the chronological limits within which the drama might have been written. King Śivamāra I, as we have already seen, lived for one hundred years from A. D. 625 till 725. Supposing that he attained to literary perfection only in the middle or latter part of his life, and that he commenced to write after his accession to the throne in A. D. 670, it would mean that he wrote the first part of the drama in the last quarter of the seventh and the first quarter of the eighth century. In other words, the first part of the drama could not have been written earlier than the middle of the seventh century. And since king Śivamāra II reigned from 797 till 815, we may reasonably assign the second part of the *Mk.* to the last quarter of the eighth century, when that monarch's military victory over the Rāṣṭrakūṭas had earned for him a great name and had brought peace and prosperity to the Ganga kingdom. That this wide stretch from the last quarter of the seventh to the last quarter of the eighth century, which was taken by the two royal authors to complete their great work, is not adversely reflected in the style of the drama is due to the genius of Śivamāra II, whose extraordinary literary skill bridged the two periods in a manner which has baffled the literary world.

¹⁰³ Narasimhacarya, *Kavicharite*, I, p. 56. *Ibid*, Intr. pp. XI-XII for the grouping of these Dravidian languages by modern Philologists,

¹⁰⁴ Keith, *Skt. Drama*, p. 130,

III. (C) THE PROBLEM OF SOME TECHNICAL WORDS

In addition to the above problems of the authorship and the date of the drama, we have another one which may also be treated from an historical point of view. This relates to some of the technical words like *Bhaṭṭāraka*, *Rāṣṭriya*, and *Kāṇeli*. The word *Bhaṭṭāraka*, for instance, has been interpreted by scholars in various ways. In one context it is supposed to mean "master," and in another, "people!"¹⁰⁶ This is inadmissible from an historical standpoint. Whatever may be the meaning which lexicographers in later times attached to this word, we have definitely historical evidence in regard to its usage. When we meet it for the first time in the Gupta inscriptions, it is used in the sense of *Parama-Bhaṭṭāraka*, as one of the titles of the Gupta monarchs.¹⁰⁶ In the history of the Deccan, the word *Bhaṭṭāraka* is said to have been only an amplification of the word *Bhaṭāra* or *Bhaḷāra*, which was used in connection with goddesses, religious leaders, titles of kings, and ordinary men. The Kavajgeri stone inscription found in the Rōṇ tāluka, Dharwar district, and dated A. D. 933 mentions a Bhaṭāri *degula*, or temple of (the goddess) Bhaṭāri, which received a specified gift from an official called Ballajjya, the Gāmuṇḍa of Kavujageri.¹⁰⁷ As a title of kings, *Bhaṭāra* or *Bhaṭṭāraka* is used in the Deccan from the first quarter of the seventh century onwards. Thus the famous Western Cālukya king Pulikeśin II (A. D. 609-642) was given the title of *parama-bhaṭṭāraka* or the Venerable One. (This was of course in the Nēruru grant of (Candraditya).)¹⁰⁸ The same title *Bhaṭṭāraka* is given to the Western Cālukya king Vinayāditya in A. D. 680.¹⁰⁹ King Vinayāditya's son Vijayāditya Satyāśraya is called a *Parameśvara-Bhaṭāra* in an undated stone inscription discovered at Kurutakōṭi, Gadag tāluka, Dharwar District.¹¹⁰ That this was, indeed, one of the titles assumed by kings is proved by a record dated A. D. 767 in which the Ganga king Śrīpuruṣa II is given the same title of *Parameśvara-Bhaṭāra*.¹¹¹ As a title of priests, we have Vedavāhana Bhaṭṭāraka, the recipient of a gift of a village from a high official of the rank of a *Mahāsamanta* (named), in a record dated A. D. 879.¹¹² In a record dated about A. D. 900, a learned priest called Śākāri Bhaṭṭāraka, the *guru* of Netraśivācārya, is praised thus:— That he was a moon in the firmament of the line of pure Śaivism.¹¹³ Candramauli Bhaṭāra was the composer of a stone inscription dated A. D. 971, and found in Aihole, Bijapur district.¹¹⁴ There are numerous examples of Jaina *gurus*, who are given the title of *Bhāṭṭāraka*, which we abstain from citing here. What may be noted for our purpose is that the word *Bhaṭṭāraka* may be construed as "a Venerable One" "a Respectful One," rather than as "master" or "people," as is done by scholars.

¹⁰⁶ See Paranipe, *Mk.* p. 17, 19, 28, 29 (Trans.); p. 18 (Notes).

¹⁰⁶ See Fleet, *Gupta Inscriptions*, q. v.

¹⁰⁷ *Bombay-Karnatak Inscription*, No. 35, p. 21.

¹⁰⁸ Fleet, *D.K.D.*, p. 352.

¹⁰⁹ *Ibid.*, p. 352.

¹¹⁰ *Bombay-Karnatak Inscriptions*, No. 2, p. 2.

¹¹¹ *Ep. Car.* IV. Mb. 80. In about A. D. 750 we have another record which speaks of Śrīpuruṣa's Bhāṭāra. *Ibid.*, Hg. 4.

¹¹² *Bombay-Karnatak Inscriptions*, No. 22, p. 13.

¹¹³ *My. Arch. Rept. for 1919*, p. 29.

¹¹⁴ *Bombay-Karnatak Inscriptions*, No. 43, pp. 29-30.

In regard to the word *Rāṣṭriya*, scholars have been at pains to show the use of that word in the works of lexicographers. It has been taken to mean a military or police chief, although scholars seem uncertain as to whom to apply the term Chief of the Police.¹¹ For in another context, the word *prāṭiveśikagrhapati* is translated into a "Prefect of Police"¹¹⁶ And in still another context, we are told that *pradhāndaṇḍadhārakaḥ* was also the "Chief of the Police"¹¹⁷ Evidently this is the result of relying entirely on lexicographers without caring to know the exact connotation of some technical words. It may be remembered in this connection that an office, whether it was that of the Chief of Police or Chief of the Military, did not possess various meanings in the same century and in the same monarch's reign in the olden times in the Deccan. Historical records enable us to give some explanation of this important word. The word *Rāṣṭriya* is closely allied to the words *Rāṣṭrakūṭa*, *Rāṣṭrapati*, and *Rāṣṭramahattara*, which are all designations of officials, who were placed over provinces. In the sense of *Rāṣṭrakūṭa*, it meant, "the head man of the *rāṣṭra* or province," just as the word *Grāmakūṭa* meant "the head man of a village or *grāma*." The earliest use of the word *Rāṣṭrakūṭa* in the sense of a provincial official is met with in a record of Rāja Prithuvimalla, the son of Rāja Prabhākara. The grant is dated only in the 25th regnal year of some unknown reign; but it is rightly assigned to A. D. 663.¹¹⁸ In a later record dated A. D. 1026 of the times of the Śilahāras, we have the following officials mentioned—*Rāṣṭrapati*, *Viśayapati*, *Nagarapati*, *Niyuktānīyukta*, *Rājapurūṣa*, and *Janapadān*.¹¹⁹ In the sense of Elders (i.e., Councillors) of a Provincial Council (*rāṣṭramahattādihikaraṇaḥ*), the term is used in a record dated A. D. 609.¹²⁰ These official designations existed in the Deccan till the end of the twelfth century A. D.¹²¹ The only sense in which we could take the word *Rāṣṭriya*, which is nearest to the word *Rāṣṭrakūṭa*, is in that of a District Magistrate who had, as he has in our own days, the highest executive powers in a district. From the point of the *Mk.* and its locale, we may maintain that the use of the word *Rāṣṭriya* strongly suggest the atmosphere of the Deccan, where the word *Rāṣṭra* was used for about seven centuries in connection with provincial administration.

There is another word in the *Mk.* which requires likewise an explanation. It is *Kānelinūtāh*, which has been interpreted to mean "Son of Kāneli."¹²² The word is taken to refer the King's Brother-in-law. Let us first take the word Kāneli in general. It undoubtedly has a Deccani touch about it. Whether it is a contracted form of Kāṇahalli, just as Bōriṣli is the shortened form of Bōrihalli, and Khāṇḍvli is that of Khāṇḍavalli, cannot be made out; but there is hardly any doubt that the word Kāneli has a strong philological affinity to some of the Deccani words like Kāṇeli, Kāṇelli, Kāṇalli,

¹¹⁵ Cf. Paranjpe, *Introd. to Mk.* pp. XXII-XXIII; Trans. p. 69; Text, p. 80; Notes, p. 49.

¹¹⁶ Paranjpe, Trans. p. 99; notes, pp. 66; Text, p. 113.

¹¹⁷ Paranjpe, Trans. p. 110; Text, p. 127.

¹¹⁸ Fleet, *D.K.D.*, p. 334.

¹¹⁹ *Indian Antiquary*, V. p. 278.

¹²⁰ *Ep. Indica*, XII, p. 130.

¹²¹ Cf. Altekar, *The Rashtrakutas and Their Times*, pp. 158-159.

¹²² Paranjpe, Trans. p. 14; Notes, p. 20; *Introd.*, pp. XXIII. Ryder's translation of the word Kāneli into Jackass (*Little Clay Cart*, p. 14) is altogether erroneous.

and Kāṇṇahaḷḷi, which are met with in epigraphs as the names of villages.¹²³ As regards its meaning, V. G. Paranjpe, after refuting some of the interpretations given by scholars, and after maintaining that it is a word which does not occur in Sanskrit literature, concludes that it is a metronymic like Gautamīputra, Vāsīṣṭhīputra, and Mātharīputra found in the inscriptions of the Āndhrabhrityas, and like the words Yādavīmātaḥ, Saurāṣeṇīmātaḥ, and Sumitrāmātaḥ occurring in the plays of Bhāsa. He takes this word to be "the proper name of Samsthānaka's mother, who need not be unmarried."¹²⁴

This explanation should be normally satisfactory to students of Sanskrit literature; but we may venture to give its historical explanation, in view of an interesting point suggested by it. We have just said in the preceding paragraph that the word Kāṇḍeli has a strong resemblance to some of the names of villages in the Deccan. If this resemblance were accepted, and if we were to refer the word Kāṇḍeli to a village of that name, then, it ill fits in with the suffix *mātaḥ*. We have, therefore, to find out whether the word Kāṇḍelimātaḥ could not be interpreted in a more rational manner. This could be done if we were to note that the ending *mātaḥ* is the exact Sanskrit equivalent of the Dravidian word *amma*. We have to find out whether men in those or in later times had names, which ended in this seemingly feminine suffix of *amma*, which stands for mother. We have already cited the example of a brave soldier called Nāgamma of the Kayva-vamśa, who died in a battle in the seventh century A. D. In the Aṇṇigeri stone inscription dated only in the 6th regnal year of the Western Cālukya king Kirttivarman (A. D. 746-757), we have Kaliyamma, the Gāmuṇḍa of Jebulageri, commemorating the construction of a Jaina temple (*cediya, caitya*).¹²⁵ Gāmuṇḍa Sāmi Kalteyamma granted a specified gift of land and money to certain people in A. D. 941, in the reign of the Rāṣṭrakūṭa king Kṛṣṇa III.¹²⁶ In A.D. 980 we have a learned *śākta* scholar called Ereyammaṇ-Dikṣita, in the reign of the Western Cālukya king Āhavamalla Nūrmuḍi Taila II.¹²⁷ In an undated record of the Rāṣṭrakūṭa king Prabhūtavarṣa Jagattunga Govinda III, there lived a man called Ecamma.¹²⁸ In another record dated A.D. 907, we are told that Māyiramma was the governor placed over the district of Muḷgunda Twelve, in that year in the reign of the Rāṣṭrakūṭa king Āmoghavarṣa.¹²⁹

These examples are enough to prove that there were names of men which ended in the suffix *amma*, which sometimes, no doubt, took the form of *amman*. If this is admitted, it is not unreasonable to suppose that in like manner Kāṇḍelimātaḥ could have been merely the name of a man, the suffix *mātaḥ* standing for the Dravidian *amma*, and that it need not be interpreted to mean the "Son of Kāṇḍeli," as has been done by scholars. It is too premature for us to maintain that Kāṇḍeli could be taken to mean the name of a dynasty. But it is evident from the drama that the King's Brother-in-law belonged to an

¹²³ M.A.R. for 1912, p. 49; *Ep. Car.* IX, Bn. 122; III, Ng. 82, etc.

¹²⁴ Paranjpe, *Intr.* p. XXIII.

¹²⁵ *Bombay-Karnatak Inscription*, no. 5, p. 3.

¹²⁶ *Ibid.*, no. 30, p. 24.

¹²⁷ *Ibid.*, no. 45, p. 30.

¹²⁸ *Ibid.*, no. 6, p. 3.

¹²⁹ *Ibid.*, no. 28, pp. 16-17.

ancient and great family (Act VIII). We do not know whether the word Kāṇeli had anything to do with the Kannuḷa-vamśa, or the dynasty of Kannuḷa, which figures in A. D. 1208.¹³⁰ It is not unlikely that the earlier word Kāṇeli might have taken the shape of Kannuḷa in later ages.

III. (D) THE PROBLEM OF UJJAIN AND THE ASVAMEDHA SACRIFICE

The fact that the scene of the *Mk.* is laid in Ujjain has led some scholars to maintain that the author must necessarily have hailed from the northern regions, perhaps from Mālwa itself. But this is altogether a fallacy: there is no ground for assuming that because an author selects a particular city for the scene of his action, he must necessarily be a native of that city. It would be as absurd to think of king Sūdraka as a native of Ujjain, because he has laid the scene in that city, as it would be to think of Shakespeare as a native of Venice, because he selected Venice as the city where the action of *Merchant of Venice* is laid! King Sūdraka's genius lies precisely in the fact that he cleverly put the contemporary world and posterity off the track by laying the scene of action of his drama in a city which was, from many points of view, one of the most romantic spots in the whole of India. But it must have been apparent to the reader that there is nothing in the drama to warrant the assumption that king Sūdraka was ever a resident of Ujjain, or that he ever belonged to northern India. On the other hand, all evidence in the drama conclusively proves that the royal author of the first part of the *Mk.* was essentially a southerner.

The mention of the *asvamedha* sacrifice is an equally clever attempt on the part of the author to baffle posterity. There is no historical proof of that famous sacrifice ever having been conducted by any Deccani ruler in the seventh century, when the political situation made it impossible for any king to celebrate that ancient sacrifice in the traditional manner. If at all we could hazard to say anything, it is that the ruler performed an *asvamedha* sacrifice in the allegorical manner as given, for instance, in the *Cchāndogya Upanisad*.¹³¹

¹³⁰ *Ibid*, p. 56. The absurdity of maintaining that the King's Brother-in-law was the "Son of Kāneli" is apparent when we try to Sanskritize a similar word ending in *amma*, thus—"Kātemātak" for Kalteyamma!

¹³¹ Read Macdonell, *Skt. Lit.*, p. 235.

JESUIT LETTERS AND INDIAN HISTORY

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INTRODUCTION

"I SEE the time approach," wrote a famous historian, "in which we shall no longer have to found modern history on the reports even of contemporary historians, except in so far as they were in possession of personal and immediate knowledge of facts ; still less, on works yet more remote from the source ; but on the narratives of eyewitnesses, and the genuine and original documents."¹ It is indeed true that modern history—not all of it, unfortunately—has come to insist a great deal on the need for adequate documentation for the facts and theses it expounds, and further, on the reliability and genuineness of these documents themselves. But while this trait of recent historical work, taken by itself, would have tended perhaps to make history a wearisome compilation of dates, cross-references and foot-notes, another characteristic of recent historical study has helped to save us from this fleshless spectre : it is the tendency to pay less attention to the mere chronology of events and to lists of rulers and their wars, and more to the forces lying behind these men and these events—atmosphere and attitudes, socio-economic conditions, religion and culture, and the innumerable host of elements that goes to make up the life of a people.

Modern historical scholarship therefore has come to rely more and more on first-hand accounts of men and their deeds, preferring at the same time that these accounts should be alive and real, pulsating with the life of the people of whom they speak. It is in the light of these two qualities that this essay proposes to examine the importance of Jesuit letters in the study of Indian History.

THE JESUIT LETTERS

What are the Jesuit Letters ? I can do no better in the way of an answer than to quote the words of the Rev. H. Heras, S. J. on the subject : "In point of fact the first injunction about letter writing among us, comes from the very pen of our founder St. Ignatius of Loyola. In the Constitutions of the Society of Jesus which he wrote in Spanish there is the following passage, which I translate directly from the original : 'It will be of great help (to the members of our Society) the writing of letters between the subjects and the superiors ; which custom will

¹ Ranke, quoted by J. Brodrick, *The Month*, Vol. CLXVII, N. 861.

cause a thorough knowledge about each other, and about the news and events narrated (in those letters) that come from different parts. About which (letter writing) the superiors and in particular the General and the Provincials will take a special care. They will order the things in such a way as to obtain that in every place, they should know about the things that are being done in other places, which is a source of mutual consolation and edification in Our Lord.²

"St. Ignatius therefore lays stress on the importance of letter writing. Not long after him, letter writing amongst the Jesuits was systematized, and as such it is found in the Declarations appended to the Constitutions. It was consequently ordered that every four months from every house of the Society they should write to the Provincial about the things that have happened in the past four months; and the Provincial should send the General a copy of these letters while other copies of the same should be sent to the other houses of the Province."^{3,4}

It is quite obvious that these letters are not the transactions of a Historical Society but deal primarily and essentially with the work of the Jesuits, but since this work cannot be well understood without a knowledge of the background in which their labours for the Catholic Faith are set, it is useful, almost necessary, to give some idea of this, and hence the importance of these letters in the writing of even secular history. Says Payne in this connection: "The range of their outlook naturally determined the range of their letters. These were written for the purpose of keeping the Superiors of their Order in touch with the Missions, and informed as to the progress that was being made. They may, in fact, be described as progress reports, or collectively, as 'official correspondence.' The references they contain to the public affairs of the day are, in consequence, few in number, and relate, with rare exceptions, only to circumstances that came under the personal observation of the writers, or had a direct bearing on their lives, or the work of their calling. The information contained in such references is sometimes detailed and of great value: in other cases, and these are unfortunately the more numerous, it is disappointingly meagre and vague."⁵

Very often these letters were written in great detail. The love that the members of the Society have always borne one another, the desire to share joys and sorrows, to expose needs and seek advice, would tend to make them so. But there is another evident reason for their length, it is the time these letters took to reach their destination; it is worthwhile hearing an account of this from a missionary himself: here is what a Spanish Jesuit wrote from Cancheu, China, describing the manner, and times, how letters are sent from the Orient to Europe, and from Europe to the Orient: "The advice boat leaves in December of this year, viz., 1689, from Macao it takes three months to go to Goa, so that it arrives in that city in March. The letters are kept waiting the whole of the year 1690 in Goa. Thereafter they leave Goa in January,

² *Monumenta Historica Societatis Jesu*, LXIV, *Monumenta Ignatiana, Sancti Ignatii de Loyola Constitutiones Societatis Jesu*, II, Part VIII, c 1, No. 9, p. 621. (Rome, 1926).

³ *Ibid.* *Id.*, p. 623.

⁴ H. Heras, S. J. *Jesuit Letters and Accounts* (Reprinted from the papers to be read at the 18th Session of the Indian Historical Records Commission, Mysore, 1942), p. 1.

⁵ C. H. Payne, introduction to *Akbar and the Jesuits*, p. xl.

1691, and arrive in Lisbon in September of the same year, and thence in a month or two they are received in Aragon in October, 1691. From Aragon they answer in January or February, 1692; these letters arrive in March in Lisbon, in which month or at the beginning of April the ship for India leaves and arrives in Goa, in the same year, 1692. The letters wait there till April, 1693, when they leave for Macao, and in three months they arrive there. And so, the letters written in Spain, 1692, are received in Macao in August, 1693, and thence they are sent to the Fathers who are here in China. In this manner it is clearly seen that four years are necessary for an answer to be received to a letter, with the provision that in this calculation there may be some slight difference, more or less, depending on the state of the sea and winds."⁶

Four years! This was in 1689, and a hundred years and more before, when the Jesuits first arrived in the East, conditions were worse if anything, and letters from India would take about a year to arrive at their destination.

Nor is it difficult to see that the Jesuits did their work with their usual thoroughness. Their worst enemy will not accuse them of negligence, and the obedience which characterises the Order would make them all the more eager to fulfill the instructions of their Founder. And that they did so in fact is shown by these words of Fr. Monserrate, author of the *Mongolica Legationis Commentarius* :

"For this and many other reasons, ever since the days of our Father Ignatius of happy memory, who was the first to prescribe it, it has become customary in the Society of Jesus to write down whatever occurs. Roderic Vincentius, the Superior of the Province of the Society in India, what time we set out to go to Zelaldin Equebar, King of the Mongols, charged me to record whatever would happen, both on the way and during our stay with the king. The nature of my calling and the rule of the Society imposing on me the obligation of obeying to the letter, I so conformed to his order that, every day, at night, for full two years and a half, I committed to writing the events of that day. In this daily labour of a chronicler, I have described the various particulars which my travels and circumstances brought under my notice. These are : rivers, towns, countries, the customs and manners of peoples, temples, religions...the Chabul war..."

The *Commentarius* is not one of the letters we are speaking about, but the painstaking care here evinced would certainly not be lacking in the letters either.

The popularity of the letters, from the interest that Catholic Europe took in the spread of the faith, and the more general interest in the newly-discovered East, was greater than we can now imagine. Nor was their influence small, and it is not difficult to believe that many a young man

⁶ From the extract of a letter to be found in *Voyages and Travels*, Vol. 3, Part II, Catalogue No. 758, Maggs Bros. Ltd., London. I take this opportunity to thank Messrs. Maggs Bros. for their kindness in keeping me posted with their catalogues of voyage and travel documents.

⁷ *Memoirs of the Asiatic Soc. of Bengal*, Vol. III, no. 9, p. 518. (*Jesuit Letters and Allied Papers on Mogor...*, ed. by Rev. H. Hosten, S. J.)

first felt within himself the call of Christ to the Society when reading one of those moving letters of St. Francis Xavier, so full of zeal and charity.⁸

We do not propose to deal here with a second kind of Jesuit writing, the "accounts" or "histories," they are also very useful to the historian: "These histories were written by learned Jesuits in Europe who had access to first-hand authorities, and they were compiled with considerable skill and fidelity."⁹ The work of Fr. Monserrate, though not really a letter of the kind we speak of here, could have been dealt with in this article as being a first-hand account of Indian affairs, but time and space preclude it; the interested reader will find the subject well studied by the Rev. H. Hosten, S.J. in the work aforementioned. The question of the "accounts" and "histories" is dealt with in Fr. Heras's article.

THE PUBLICATION OF THE LETTERS

Before proceeding to discuss the importance of the Jesuit letters, a brief account of their publication and present whereabouts will not be out of place. The edification they could give and the information they contained inclined the Superiors of the Society to have them published and accordingly in 1581 the *Litteræ Annuæ* or Annual Letters (they were sent to Europe, and often published, yearly) were first published in Rome. With a break between 1614-1650, the publication of the *Litteræ Annuæ* was discontinued for good in 1654, by which time forty volumes had been published. In 1899 a periodical publication under the general title *Monumenta Historica Societatis Jesu a Patribus ejusdem Societatis edita*, (Historical Documents of the Society of Jesus, published by the Fathers of the same Society) was started in Madrid and continued till 1929, when the headquarters of the publication were transferred to Rome and it was converted into an international concern. The collection of Xaverian documents (*Monumenta Xaveriana*) published in this series is of great interest to students of Indian History.

The letters that the scattered Jesuits sent to Rome from the four corners of the world were often published unofficially by Jesuits and others. It is practically impossible, and unnecessary in this short essay, to catalogue all the letters referring to India published in this unofficial manner. We mention however Lockman's *Travels of the Jesuits* (Two Volumes) not because it is the most valuable but because being in English it is probably better known in India. The editor in the dedication qualifies the Jesuits as "a body of Men whose literary Productions will be as acceptable to you as the Tenets and Practices ascribed to them must be distasteful;"¹⁰ the book contains several letters referring to India. C. H. Payne has also two books where Jesuit documents though not letters provide the main, or rather all the material.¹¹

⁸ "A friend sent me from Rome a copy of a letter of Master Francis Xavier in which that eminent Father relates the abundant and wonderful fruit of souls given by the Lord, and thanks God for the confirmation of the Society of Jesus by the Holy See.

At those words I began to wake up as it were from a long sleep, and found myself stirred to the depths of my soul..." Fr. J. Nadal, S. J., famous educationist; quoted by J. Brodrick, S. J., in *The Origin of the Jesuits*, p. 202.

⁹ MacLagan, *The Jesuit at the Mughal Court*, pp. 5-6.

¹⁰ Lockman, op. cit. (London, John Noon, 1743), p. i.

¹¹ C. H. Payne, *Akbar and the Jesuits* and *Jahangir and the Jesuits* (The Broadway Travellers; G. Routledge & Sons, London).

But if the published letters of the Jesuits are numerous, the unpublished are perhaps still more so. In his article Fr. Heras lists a number of place where these may be found. In brief they are: the Archives of the Society of Jesus in Rome, perhaps also the Archives of many Jesuit Provinces and houses specially in Portugal and Spain; the British Museum and in particular the Marsden Collection; the National Archives of Lisbon and perhaps of Spain also; the National Archives at Goa;¹² finally in private collections, Jesuit letters from which appear in the market from time to time, as can be seen from the catalogues of Messrs. Maggs Bros., London. Incidentally many of these important letters have yet to be translated into English; the present author has made some efforts in this direction and hopes to publish the results of his work in the course of time. A reference to Jesuit bibliographies will not be out of place: "The erudition of the Jesuits has been nowhere more markedly displayed than in the bibliographies which have been prepared of the literary out-turn of the members of the Society,"¹³ these are extremely useful in any investigation of Jesuit documents. They date from Ribandaneira's (1602, 1608) to Sommervogel's (1890). This latter with supplements by Fr. Riviere, remains the standard work for reference.

THE VALUE OF THE JESUIT LETTERS

Lest it should be thought that the Jesuit Letters are just a hobby-horse of ours and that we are labouring the point of their value, it may be advisable to begin by stating that the importance of Jesuit documents in the history of other countries besides India has been widely recognized. To take one single instance we have the Jesuit Relations of Canada. These documents, published yearly, 1632-1673, embrace letters sent by Jesuit missionaries in America to their brethren in Europe, and form the most important, and often the only material for the history of Canada for that period. Some of these volumes became so rare that they could not be found even in the great libraries of Europe. The Canadian Government, realizing the historic value of the Relations, assembled and reprinted them in three large octavo volumes in 1848. A further tribute to the value of these documents is the Thwaites edition of the Jesuit Relations and Allied Documents, seventy-three volumes, published in 1896. Non-Catholic historians, in searching for documents bearing on the early history of North America, gradually became acquainted with the Jesuit Relations, and discovered in them a mine of information and of heroism. They then began to make known to the world at large the priceless treasure which they had found. Parkman, in particular, gave to the world his history of the Jesuits in North America (Boston, 1878), where he says: "Though the productions of men of scholastic training, they are simple and often crude in style, as might be expected of narratives hastily written in Indian lodges or rude mission houses in the forest, amid annoyances and interruptions of all kinds. In respect to the value of their contents, they are exceedingly unequal. Modest records of marvellous adventures and sacrifices, and vivid pictures of forest-life, alternate with prolix and monotonous details of the conversion of individual savages,

¹² From personal investigation we are fairly sure this source has been completely depleted, and that there remain no original letters there now.

¹³ MacLagan, *The Jesuits and the Great Mogul*, p. 10.

and the praiseworthy deportment of some exemplary neophyte. With regard to the condition and character of the primitive inhabitants of North America, it is impossible to exaggerate their value as an authority. I shall add, that the closest examination has left me no doubt that these missionaries wrote in perfect good faith, and that the Relations hold a high place as authentic and trustworthy historical documents."¹⁴

And the value of the Jesuit Letters from India is surely not far behind these, and it is to the credit of modern historians that they have recognised this fact, and their unanimity of opinion is in itself a proof of the worth of these letters. To list their appreciations would be tiresome, here are just two instances : says Vincent Smith, "Failure to read the Jesuits has resulted in the currency of much false history. The Fathers were highly educated men, trained for acute observation and scholarly writing. They made excellent use of their opportunities at the imperial court, and any book which professes to treat of Akbar while ignoring the indispensable Jesuit testimony must necessarily be misleading,"¹⁵ and Maclagan, "...they emerge from the examination with the greatest credit and may for historical purposes be looked on as authorities of a very high order."¹⁶

We have already remarked that one of the characteristics of modern historical work is *aliveness*. The Jesuit letters are certainly very much alive. It is not difficult to imagine the difficulties and dangers that the priests of the Society had to undergo in their labours for the spread of the Gospel in those early years in India, and while describing these the letters contain much interesting first-hand information about the different countries where they were labouring, of men and manners, religions and idols, politics and pageantry. The Fathers were new to India hence all was of interest to them, as curious and cultured investigators, all full of novelty—the aspect of the land with its eastern panoramas, the climate and the soil full of a foreign vegetation, the customs and the cults of the people, their dialects and idioms, their very features and mode of dress—all this impressed the Jesuits very vividly, and their correspondence reflects like a mirror of varying clarity the different phases of Indian life and character, making thus their letters so interesting and important. "As contemporary records, they are redolent of the atmosphere of the period. They familiarise us with the common sights and the little everyday occurrences which are seldom part of the stock-in-trade of the professional historian, but which do more than anything else can do to bridge the gulf between the present and the past. Incidentally they bring us into touch with the administrative machinery of Akbar's kingdom, and introduce us to various types of state officials..., shedding many interesting sidelights on the duties they performed, and in the manner in which the law of the land was administered. At the same time they illustrate, better than any other part of the *Histoire*, the daily life and surroundings of the humbler classes of people."¹⁷

¹⁴ Preface, pp. V-VI. Quoted by Martin Scott, S. J., *Isaac Jogues, Missioner and Martyr* (P. J. Kenedy & Sons, New York, 1927), p. XI.

¹⁵ Smith, *Akbar, the Great Mogul*, p. 7.

¹⁶ Maclagan, *The Jesuits and the Great Mogul*, p. 18.

¹⁷ Payne, *Akbar and the Jesuits*, p. XLII : speaking of the stories and incidents narrated in du Jarric's work. The remark applies very well to the Jesuit letters,

We may here refer to another trait of these letters which enhances as well as, in another way, lowers their historical value. It is what has already been stated before, that the Jesuits did not mean to write history, "the attitude of the Fathers towards the general affairs of the Empire was one of indifference." This "attitude of indifference" while ensuring on the one hand impartiality, and an objective account of men and events, would tend on the other hand to the omission of descriptions of events of solely political importance and perhaps to an acceptance of reports regarding these events without adequate verification. But of this more later, meanwhile let us bear in mind this attitude of impartiality of the Jesuit mind towards Indian events.

A further claim which the letters possess is their range in time and space. From the arrival of Xavier in 1542 down to the days of the suppression of the Society at the end of the eighteenth century, the letters provide a shifting panorama of Indian events. Their study is essential to obtain a clear view of the Mughal period, so critical for India, all the more so since they cover a period where other documents are scanty.¹⁸ And the letters are also important for the study of the years of Portuguese rule in India.¹⁹

Nor are they less extensive as regards space. As befitted their pioneering genius, the Jesuits covered the country from Comorin to Kashmir and went beyond, into the vast unknown of Tibet, and from the west coast to Bengal. Andrade, Goes, Fenicio, Monserrate, are names with which no student of the history of Asia can afford to be unacquainted—these men entered, centuries ago, lands which baffle the explorer even to-day.

Next, let us remember who the authors of these letters were : not uneducated adventurers who were just passing through the country, but men of learning and culture who made India their home. "I believe it will be granted, that no Men are better qualified to describe Nations and Countries than the Jesuits. Their Education, their extensive Learning ; the pains they take to acquire the Languages of the several Regions they visit ; the Opportunities they have, by their Skill in the Arts and Sciences, as well as by their insinuating Address, to glide into Courts, where Access is often denied to all but themselves ; Their Familiarity with the Inhabitants ; their mixing with, and, often, very long Abode among them ; these, I say, must necessarily give our Jesuits a much more perfect Insight into the Genius and Character of a Nation, than others who visit Coasts only, and that merely upon Account of Traffic or from other lucrative Motives."²⁰ That the Jesuits were men of learning and culture will be readily granted we are sure ; that they had the necessary background of history and geography for their survey is also evident ; that they took the trouble to learn the language and the custom of the people the works of de Nobili, Beschi, and Fenicio amply prove. But they have a further claim to be believed : their familiarity with the

¹⁸ Cf. *Akbar, the Great Mogul*, p. 260 ; MacLagan, *The Jesuits and the Great Mogul*, p. 52 ; Payne, *Akbar and the Jesuits*, p. XLIII.

¹⁹ Guerreiro's *Relação*, edited by Antonio Vieira (Coimbra, 1930). Introduction, p. XII.

²⁰ Lockman, *op. cit.*, p. VIII.

rulers of India (the relations between Beschi and Chanda Sahib are a striking illustration) which would enable them to get first-hand news not from the court alone, but also from the various states through which they accompanied the sovereign; but while familiar with princes, they were in no sense courtiers, hence free from the temptation to flattery, adulation and deceit to which these are exposed²¹; that the facts set down are not mere figments of Jesuit imagination, but the considered work of men and prudence and judgment will be quite clear from a perusal of Monserrate's introduction to his *Commentarius*. Their long stay in India enabled the Fathers to be in touch not only with the princes, but with the people as well. In the South specially, Jesuit missionaries living as Indians among Indians were enabled to gather much useful knowledge not only of their manner of life, but also the more important intimate knowledge of their character.

A last argument in favour of the letters is the confirmation of the information they contain by contemporary historians and local tradition. To take only a few instances—Monserrate's description of Afghanistan has been proved to be remarkably accurate²²; several events mentioned in the letters can be checked against the statements of Hawkins,²³ Thomas Jones,²⁴ and even Badaoni himself,²⁵ while Jahangir's own memoirs provide a means of verification; finally local tradition often confirms what the Fathers had to say about these places and their customs.²⁶

Let us conclude by stating quite clearly that we do not claim anything like infallibility for the Jesuit letters. The authors were men, and, like the rest of their race, subject to error. Though few Europeans got so close to the soul of the people as did de Nobili and Fenicio, yet it is possible that a foreign upbringing might have made some of the Jesuits unconsciously unsympathetic to Indian manners and customs. Though few, if any, of the early visitors to India took the trouble to study the languages of the country as did Stephens and Beschi, yet it is possible that unfamiliarity with the languages spoken around them led to some mistakes in the collection and interpretation of facts by the Fathers. Though widely-travelled in India and in close touch with its affairs, yet it is possible, as we said before, that not being historians essentially, they omitted to mention important political events in their letters. Finally, in the compilations made from the letters, further errors of omission, translation and interpretation may have crept in. No, the Jesuits were not

²¹ "I cannot, however, resist giving you some more quotations from the accounts of the Portuguese missionaries. Their opinions are of far greater value than those of courtiers. . . ." Pandit Nehru, *Glimpses of World History*, p. 312 (1942 ed.).

²² Cf. H. Heras, S.J., *The Jesuits in Afghanistan* in the *New Review*, Vol. I, Nos. 1 & 2, Jan-Feb., 1935.

²³ Cf. Payne, *Jahangir and the Jesuits*, pp. 80 and 111.

²⁴ *Ibid.*, pp. 86 and 115.

²⁵ Cf. E. D. Maclagan, *The Jesuit Missions to the Emperor Akbar*, *Journal of the Asiatic Society of Bengal*, I, 1, 1896, p. 70.

²⁶ Payne in his *Akbar and the Jesuits* has made a case against du Jarrie's account of the fall of Asirgarh. We have not investigated the matter since du Jarrie's work is outside the scope of this paper, nor has it been proved that his account has been taken from any Jesuit letter (Payne himself says it is difficult to believe it is), and it is with these that we are concerned. For the Jesuit account of the siege cf. the Rev. H. Heras's article in "The Indian Antiquary," Vol. LIII, 1924, pp. 33-41.

(and are not) infallible—if every historian had to be that there would be no histories left on our library shelves ; we are content to hold that they are reliable, very reliable indeed, and, specially in view of the lack of other documents, among the most important sources for the study of Mediaeval Indian History.

CONCLUSION

“It has been said, and we think rightly, that if the Relations of the Jesuit Missionaries in Northern India during the XVIIth and XVIIIth centuries were published, they would to some extent revolutionize the History of the Moghul Empire. What is true for the North, would be no less so for the rest of India ; all the more, if the various Religious Orders which laboured in India during the first three centuries of the Conquest—Carmelites, Franciscans, Dominicans, Augustinians, Theatines, Jesuits, Foreign Missionaries of Paris—were to combine to rescue from the dust of their libraries their long accumulated wealth of precious MSS. and rare in-folios. No doubt, we should stand confronted with a hard and heavy undertaking ; but in these days of monumental enterprises, it would not be unfeasible.

“The publication of the Jesuit Relations of North America .. was completed in 1902...

“The ‘Annals of the East India Catholic Missions’ would be an even more voluminous store-house of historical materials—profane and religious—unparalleled in breathless interest.”²⁷

Yes, a lot of work remains to be done in the field of research—up to now only a mere handful of historians has made any use of the Jesuit documents—but not before this much-neglected mine of historical evidence has been fully explored can the last word be written on Mediaeval India. It will be tedious hard work no doubt, but it will be worthwhile and when accomplished will remain a landmark in the writing of Indian History.

²⁷ H. Hosten, S. J., *Jesuit Missionaries in Northern India and Inscriptions on their Tombs, Agra* (1907), p, 43.

LAND VALUES IN THE MADRAS PROVINCE

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INTRODUCTION

THE gaze of the countries of the world has been now directed as it was probably never before in recent times to problems of land.

Much has been said and written in the past few months in our country about land systems and the principles of the abolition of the Zamindaries. "The stabilisation of agricultural prices" has already enlisted for itself many followers in recent years. However, the question of the prices of farmlands and building sites does not appear to have engaged serious attention of our economists, administrators and eminent persons in public life. It may be well therefore to analyse and study in brief the different aspects of the question of land values emphasising some of the main points of the discussion. Since agricultural problems are regional in character the material presented in the essay relates largely to conditions in the Madras Province.

HEAVY SINKING OF FUNDS IN LAND

Under capitalist economy, economic institutions like inheritance, credit, competition, monopoly, etc. have attained peculiar significance and the most important institution concerning land is the development of private property¹ in land. Facilities like recording of title deeds, transfer of titles, mortgages, leases and other instruments provided by government and other agencies have imparted relative permanence to rights of private property in land. Possession of land gives to the owner a status in society, besides the security of money invested. In many countries landowners or the wealthy and the propertied class generally enjoy certain privileges and political rights in the matter of voting and representation of their interests in assemblies and various public bodies. Thus a local saying goes "that possession of money or landed property is tantamount to possession of all things in the world, for ownership of land extends power over other things associated closely with landed property.

In India there are some additional factors which favour heavy sinking of funds in land (in fact, it is said to be the feature of the Indian economy since long) such as inadequate development of alternate

¹ Property is defined by Richard T. Ely "as the exclusive right to control an economic good," or as stated by Blackstone as "that sole and despotic dominion which man claims and exercises over external things of the world in total exclusion of any other individual in the Universe."

Vide—Commentaries on the Laws of England, Book II, Ch. 1.

sources of investments like industries, trade and commerce, social customs, illiteracy and the naive habit of hoarding of the people. The decay of cottage industries and increase in rural unemployment combined with the rapid population growth and its heavy incidence on the agrarian economy have also contributed in a degree to the undue emphasis attached to landed property.

As late as the period during 1942 and 1943, there was a veritable diversion of funds into landed and immoveable properties in the Province from persons belonging to all walks of life owing to the threat of the Japanese invasion and consequent loss of confidence in the paper currency and other forms of investment probably with the exception of precious metals like gold and silver. In the 'Registration Districts' of Palamcottah, Madura, Tinnevely and Ramnad districts monies brought with some of the evacuees from Burma, Ceylon and Malaya were poured in purchases of land and immoveable properties.

This phenomenon inevitably leads to certain significant effects. In the first place a large portion of wealth produced by the community is locked up; and one of the effects of rise in land values is restriction of the use of land by the agrarian classes concerned and a concomitant limitation to the natural production of wealth. High land values lead to concentration of land and capital since big landlords, businessmen or capitalists alone can afford to invest large sums for purchases of land. Land is being transferred rapidly from the cultivating owners to the moneylenders, merchants and big landlords, while the lands of the petty ryots, the petty salaried and the professional classes are progressively swallowed up, throwing them into the ever-growing bulk of the rural or the urban proletariat leading to serious economic and social consequences.

GENERAL RISE IN LAND VALUES

In an old agricultural country like India with its increasing demographic pressure in face of limited supply of desirable land, the rise in land values is certain. Marshall observes "As the best part of the New world get taken up, there will be probably a rise in the value of almost all lands."¹ All improvements in transport and communications, all private, municipal or national undertakings extending greater facilities for exchange and for quicker and better distribution of goods, all scientific and technological developments in agriculture as well as in industry and indeed all social economic and national progress cause a general rise in land values. Similarly, improvements in the general standard of cultivation as adoption of better methods of cultivation of crops and crop rotation, the better utilisation of farm lands, the physical impact of towns and urban growth on country side and the general trend of rise in the price levels of all goods and services generally during the last few decades are reflected in a marked rise in prices of land. Urban and rural land values have risen and still continue to rise. In fact the rise in prices of land is inevitable and have to record an increase in any progressive country with its general progress, increase in population and national wealth.

¹ Vide Principles of Economics, p. 686,

Table No. 1 below indicates the average rate per acre of the sale values of land for the various classes of soils in the district of Chingleput during the period 1896 to 1930.

TABLE No. 1

Description of soil	1896-1900 (in Rs.)	1906-1910 (in Rs.)	1916-1920 (in Rs.)	1926-1930 ¹ (in Rs.)
Red loam, tank, riverfed ..	132	234	325	388
„ „ rainfed ..	77	154	285	398
Red sand, tank, riverfed ..	109	116	649	227
„ „ rainfed ..	64	99	201	505
Black loam, tank, riverfed ..	353	415	486	548
„ „ rainfed ..	196	302	431	762
Black clay, tank, riverfed ..	152	214	186	247
„ „ rainfed ..	135	150	192	749
Black sand, riverfed ..	170	152	410	483
Red loam with well ..	116	157	347	167
„ without well ..	34	60	168	156

Statistics presented in the table disclose that broadly speaking the value of wet land has trebled and that of a dry land more than doubled in the period of an single generation.

LAND BOOM DURING WAR YEARS (1939-45)

Agriculturists' estimates about the value of farmlands have risen steeply during war years and the land boom created since the outbreak of the war reached its peak in the year 1943 in the province. Under the present framework of abnormal price levels and money returns from land some ryots appear to be too optimistic to visualise a set back in the prices of agricultural produce and farmlands in the foreseeable future. Prices of commercial crops like tobacco, groundnuts, chillies, oilseeds and sugarcane and to a certain extent prices of pulses and food grains have registered a sharp increase in recent years. Considerable diversions of cultivated areas from the food crops to the special crops have already taken place leading in no small measure to the deterioration in the food situation of the province. The prices of these lands are noted to have risen in certain cases more than the proportionate rise in the commodity prices and the increase in the net returns obtained from such lands.

Table No. 2 shows the prices of farmlands, classified into dry, wet and garden, in the years 1939 and 1945 and the percentage increase in their values during the period in some districts.

¹ Sec. The Statistical Atlas of the Madras Presidency, 1936, p. 493.

Note:—In each of the red and black soil groups suited for crop cultivation, loam is considered the best, clay next in order and sand the worst. The red soil predominates in the north and the black in the southern taluks which are more fertile. Tanks form the principal source of irrigation in the district and wells supplement irrigation particularly under small tanks.

TABLE No. 2*

Taluk	Region	Average sale value of land per acre in 1939			Average sale value of land per acre in 1945			Percentage increase in average sale value of land in the period		
		Dry (in Rs.)	Wet (in Rs.)	Garden (in Rs.)	Dry (in Rs.)	Wet (in Rs.)	Garden (in Rs.)	Dry	Wet	Garden
Palkonda	Vizagapatam	300	525	..	650	875	..	117	67	..
Narsapur	W. Godavari	250	900	1,200	600	2,500	3,500	140	178	192
Guntur	Guntur	300	500	..	1,000	1,200	..	233	140	..
Kavali	Nellore	200	600	..	450	1,400	..	125	133	..
Madanapalli	Chittoor	150	300	..	350	650	..	133	117	..
Adoni	Bellary	200	400	..	500	900	..	150	122	..

(Source : Personal investigation)

*The accuracy of the results in the table may be improved by presenting further statistics with regard to average values of lands situated in different natural agricultural divisions of particular sample villages or group of villages selected.

ANALYSIS OF RISE IN LAND VALUES OF DIFFERENT
TYPES OF FARMLANDS

It is evident from the table that the rise in land values is relatively higher in the deltas and well settled regions than in dry areas like the Ceded Districts and other regions where crop failures are frequent. Secondly, in those dry tracts where there is some degree of certainty of harvests, the percentage increase in prices of dry land is much higher than that of wet lands, since expenses of cultivation of wet lands are relatively much higher than those relating to dry cultivation especially when this difference in production costs is not made good by the corresponding differences in the relative prices obtainable for the agricultural produce raised on wet and dry lands. The high percentage increases in land values in the dry tracts of Guntur and Adoni talukas is perhaps due to enormous prices obtained from cultivation of commercial crops like tobacco, chillies, groundnut and cotton, while the rise in values of garden lands in Narsapur taluk may be also explained by the corresponding rise in the prices of lemons, plaintains, betel, turmeric, etc.

LAND VALUES AND NET RETURNS FROM FARMING

The table below shows the price of land in relation to estimated percentage of net returns on capital outlay in land for lessors and cultivating owners.

TABLE NO. 3

Nature of land-holder	Size of holding in acres	Gross value of rent or income including cost of grain, straw, etc. (in Rs.)	Incidental ² charges or expenses incurred on the holding (in Rs.)	Total net income (in Rs.)	Net income per acre (in Rs.)	Sale value of land per acre (in Rs.)	% return on capital outlay per acre
Lessors ..	{ 5 wet	790	150	640	128	3,000	4%
	{ 10 dry	600	90	510	51	500	10%
Owner-cultivator	{ 5 wet	1,070	853	217	44	3,000	1.5%
	{ 10 dry	1,250	1,025	225	23	500	4.6%

(Source : Personal investigation)

It is obvious that in absence of regulation of rents by ténancy legislation in the province the returns obtained by lessors is relatively higher than those of cultivating owners. However, due to conditions

¹ For simplification of matters, what may be considered as an economic holding in the regions concerned is taken as the size of the holding. The estimates relate to two villages, one purely wet and the other largely dry in the district of West Godavari.

² Note:—In case of a lessor, incidental charges to be borne by him include land revenue and local cesses, proportionate cost of manuring, reclamation, etc. In case of owner cultivator in addition to the above, costs of cultivation, costs of minor repairs, proportionate depreciation on operating equipment and cost of farm servant are included. The labour contributed by the owner and his family is rated as the cost of one farm servant. If interest on capital outlay is also deducted in both the cases, it may be seen that the net returns shall be further reduced.

created by war, incomes derived on capital outlay in dry lands are more than those derived from wet lands owing to difference in costs of cultivation and non-control of prices of produce raised on dry land till very recently. It may be explained, that the reason of getting lower returns from land, when compared to returns obtained from other sources of investment is perhaps partly owing to the fact that landed property is visible to all and appreciable by all with the result that it conforms to the owner relatively somewhat more influence in society than any other 'invisible' property.

LAND VALUES AND RENTS

The relation of land values and rents collected are presented in the table below.

TABLE NO. 4

Area of farm	Value of rent realised (net)	Value of farm			% of rent (net) to value of land
		Rs.	as.	ps.	
(i) 2-80 (Delta wet)	414 0 0	8,490	0	0	4.87%
(ii) 1-0 (wet)	64 3 0	1,000	0	0	6.4 %
(iii) 1-20 (wet)	57 5 0	840	0	0	6.78%

(Source: Personal investigation)

Net returns from farming depend not only on fertility of land but also on costs of cultivation and the prices obtained for the produce raised. Broadly speaking farmer's estimates of farmlands are based on the productivity and situation of a farm which influence both rents and values obtained for farmlands concerned. If it is assumed that future rents are expected to be a series of relatively stable incomes, the present value of these expected incomes is expressed by the capitalisation formula,*

$V = \frac{a}{r}$, where 'a' stands for annual rent and 'r' for the current rate

of interest. In other words supposing one acre of land is expected to yield Rs. 3,000 as rent over a long period of time, capitalised at 6% current rate of interest, would sell for Rs. 500. On the contrary, if vendors and vendees of land expect that incomes from land would increase in future, this hope would be reflected in the sale price of the farm with the result that the sale values would be screwed up still higher. The composite formula embodying both this 'anticipated value' and the 'production value' as expressed in the above formula, may be given as

$V^1 = \frac{a}{r} + (\text{or } -) \frac{i}{i^2}$, where 'i' is the anticipated annual increase in rents.

As incomes from land are anticipated to increase and also to decrease some times, the formula therefore contains both the signs of plus and minus. The estimates of land values which may be thus arrived at have some obvious defects, for instance the capitalisation formula of estimating

*See, Land Economics by Ely and Wehrwein, New York, 1940, ch. v, p. 120,

land values wholly from rents does not hold good, since rents are subject to many other influences besides productive capacity like custom and tradition, bargaining capacities of parties concerned, existence of conditions of rack renting, etc. In the same way prices paid for lands are also influenced considerably by factors other than rent, as consideration of facilities, competition and other psychological and institutional factors.

But it is well-known that land values in the province and in India taken as a whole are not rated as in the highly industrialised countries like U. S. A. or U. K. according to capitalisation rates which are based either primarily on expected net returns from agricultural land in a long series of years, or on a parity with returns from alternate sources of investments at present or on the future anticipated income situations. Lands are sold and purchased at rates governed by competition, custom and naive standards of judgment of the rural people.

ECONOMIC SIGNIFICANCE OF HIGH PRICE LEVELS

(A) *High land values in relation to productive agricultural debt :*

The seriousness of high price levels of agricultural land depend in a large measure on the nature of different sources of purchase money of lands and the extent to which the purchases are effected through debt, general or mortgage debt. If the purchases are made from fresh borrowings and mortgaging of land anticipating continued existence of high price levels, the dangers are too obvious. In fact the experience of the World War I reveals that in many parts of the world the relative prosperity and solvency of the peasantry due to high prices and some reduction in the volume of their indebtedness was transformed rapidly into an unfortunate position owing to the natural tendency on the part of the peasantry to purchase lands by borrowing.

It is stated that in U. S. A. many instances were noted of purchases of land during World War II and in its wake particularly in the cotton tracts of the South East America where the lands purchased were heavily mortgaged, the value of the mortgages was in some cases amounted to about 75% of the aggregate value of the areas purchased. It was estimated by Dr. B. V. Narayanaswamy that out of the total rural debt of Rs. 218 crores in the Province at the end of 1945, at least a sum of Rs. 27 crores must have been incurred by agriculturists during 1942 to 1945 for productive purposes such as purchases of land and improvements in land.¹ As a matter of fact in the past few years fancy prices were offered for lands. The risks involved in such a venture are clear, if incomes derived from the farm lands in future would not measure up to the expectations according to which high prices were paid for purchasing of lands, as for example in case of a serious decline in prices of agricultural produce. In the first place should prices fall sharply such so-called productive debts may naturally transform into a halter round the neck of the ryots leading to mortgages (if lands are not already mortgaged), and finally may force wholesale foreclosures of lands on the buyers concerned as in the last depression. If prices of commodities are to be maintained at existing high levels out of sheer sympathy for the purchases of lands at high prices the consumers will be hard hit. Moreover, the ryot too as a consumer

¹ The same authority estimates that there was a reduction of rural debt by about 54.21 crores during war years in the province, since the debt of Rs. 2,71.92 crores in 1939 was reduced to Rs. 2,17.71 crores by the year 1945.

wishes moderate prices for his requirements, although as a producer he may desire high prices for his farm produce, and at any rate broadly speaking very high prices are not conducive to the good of the most of the small peasants themselves.

(B) *Land values and tenancy* : When land values rise rapidly, naturally the landowners will be reluctant to part with their lands easily or defer sales to a future date in order to reap the full benefit of the increase in land prices. As long as a lessor landholder is holding his land either primarily or incidentally for the sake of disposing it at a high price, he will be reluctant either to rent out his farm on a long term lease or to make any positive agreement with regard to renewal of an existing lease from year to year, because he must be in a position to dispose of the farm at short notice, when an attractive price is offered for it. In such a case improvements made by the owner on his land add to the sale value of land, while those affected by a tenant add nothing to his financial interest as long as there is no security of his stay on the farm. In fact one of the reasons of insisting short term leases during war years may be partly attributed to the fear of the owners about the loss of the speculative element in farm values, although sometimes a stipulation is made in this province in the lease deeds stating that the lease may be considered to have become null and void, if the rented farm is sold away during the lease period. Thus the speculative element in farm values, consequent of a rapid increase in their values, is directly responsible for tenancy and its growth in as much as high prices of land and the unwillingness of landholders to sell their lands readily render it difficult for many an enterprising and hardworking tenant to acquire lands and become substantial landholders, while at the other end high land values transform many a landholder partly into farmers and partly into speculators and render conditions of duration of leases un-certain.

(C) *High values and speculation* : Thus high prices of land, rural and urban have brought into being some of the speculative tendencies recently observed in this province in farm lands and building sites which may call for a somewhat detailed discussion. Many factors have been operating which naturally encourage some of these speculative tendencies. In the first place owing to the rapid urbanisation now taking place all over the province and the continuous exodus from the villages to the neighbouring urban areas for education, health, comforts of town life, or in search of employment or some economic gain, there has been overcrowding in towns, which are growing in number and scarcity of housing accommodation as well. There has been also increase in the demand for new buildings and house sites with the increase in the number of doctors, schools, shops and even the volume of the Governmental activity during the war and the post-war years. It is noticed that as a consequence a good number of the traders, merchants and professional people are acquiring lands for construction of buildings, godowns, etc. Some are preferring in fact to dispose of a part of or whole of their farm-lands in view of the much rumoured introduction of tenancy legislation in the province and invest those funds in construction of buildings which are sure to yield them much higher returns by way of rents than the sums obtained at present as rents or obtainable under tenancy legislation.

Sharp increase of activity in this sector has naturally had led to speculation in some quarters. In the period of the so-called post-war planning, the rumour of construction of a sugar factory, establishment

of a tobacco-curing centre, cotton ginning or oil crushing factories, opening of new schools or hospitals, construction of roads, bridges, government or public buildings and the like is enough to bring about a local landboom for house sites, to create a stir in the minds of the people and a great deal of unrest among many neighbouring villagers. The speculation in urban sites appear to be very prominent in those towns which have rapidly grown into cities in recent years like Bezwada and Guntur for example. In certain parts of the Bezwada town and in its vicinity lands costing Rs. 0-1-6 to Rs. 0-5-0 a yard a few years back are now being sold at Rs. 5 to Rs. 10 a yard.¹

Instances are not uncommon where the buyers of agricultural land and especially house sites are said to have sold away the same lands at higher prices to third parties before registration of sale deeds, or immediately, or within a short period after registration. This activity is seen considerably in the districts of Guntur and the Kistna. Sale prices of farm lands in the tracts under the Tungabhadra project took a sudden leap, while land values of areas under some of the proposed irrigation schemes have already begun to soar up within a course of two to three years. The most alarming aspect of it is that considerable lands under such tracts were acquired recently at very low prices, or so to say for nothing, by outsiders who were lucky in anticipating or in possession of such knowledge much earlier than others. Some of them are either disposing a part or whole of their areas at the present high levels to others or migrating to the places concerned to settle down. Further it is also noted that in many districts small ryots are selling away their relatively more fertile bits of land in their native taluks and purchasing larger extents of poor land in the uplands or dry taluks. It is gathered that some ryots from Tenali, Guntur and Bapatla taluks in this way have acquired lands in the upland taluks of Ongole, Sattenapalli, etc. and migrated there.

Before suggesting finally measures to eliminate or reduce to a minimum some of the evil effects of speculation and high land values, it is useful to analyse the factors which influence land values.

FACTORS INFLUENCING LAND VALUES

The factors which influence the values of lands may be classified according to their nature into economic, psychological and institutional. On the economic side the chief factors which influence values of farm lands may be divisible into three sets viz. the net return from land, the security and regularity of those returns and lastly the saleability or liquidity of land as an asset or investment. To some extent the first two are interdependent and the third is largely governed by the former.

The value of crops is the main factor in determining the value of returns from land. The value of crop depends on the yield from the soil, costs of production including transport, and the market price obtained for the produce. All the elements such as fertility, climatic conditions, facilities of irrigation and drainage, methods of cropping, conditions of market, etc. which affect these three will also affect the net returns from land and hence ultimately the prices of land. Generally higher prices are paid for wet lands than for the dry; and the wet paddy lands in the deltas are perhaps the most valuable. The heavy income yielding garden lands like lemon, plantain, betel, oranges and lands raised with

¹ One yard = 9 sq. feet.

garden crops like turmeric, sugarcane, onions and vegetables are reckoned as very valuable. But it may be noted that even though plantations like tea, coffee and pepper (which are mostly under European management) may give higher returns per acre than areas under dry crops, still those lands are always rated at lower prices, since climatic conditions, the heavy capital requirements and the long period of waiting for 4 to 5 years necessary before any return is obtained render them inconvenient and unattractive for most of the people. Even though the lanka lands (or islands of silt in the big rivers) may be regarded as valuable from the point of their fertility suited to cultivation of valuable crops like tobacco, their prices are depressed owing to lack of security of returns as the lankas are submerged every year during high floods and may be swept away. A detailed discussion as to the extent costs of cultivation determine the values of lands concerned, and conversely the extent the values of land influence the proportionality of the various factors of production is not so pertinent to our present analysis. However, it may be stated that when there are difficulties of cultivation as for example, if the irrigated water is to be lifted up or baled out, it is certain that the values of such lands will be slightly discounted.

Thirdly the saleability of land is affected not merely by the net yield from land and the regularity of that yield which largely determines the value of landed property as an asset or investment, but also on the existence of a market for land. Where rainfall is precarious and sources of irrigation equally insecure, the ryots will not be inclined to spend much on farming the land and consequently the yield will be less. The harvests not only vary from year to year but after a series of bad seasons even good land may be less readily saleable as for instance some lands in the upland regions. In some of the localities in the ceded districts where the ryot population is thin and the soils poor, lands are not so attractive and they seldom enter the land market.

In some villages in the Rayadrug and Kalyandrug taluks in the Bellary and Anantpur districts respectively, it was noticed during my tours¹ that lands were so unattractive that almost nominal amounts were paid for large tracts of lands even in the land-boom years.

For instance from the sale deeds examined in the office of the Sub-Registrar, Rayadrug, it was found that in the Hosalli village a 'pujari' disposed of about 26.78 acres of Srotriyam land (Inam) consisting 6.04 wet and 20.74 acres dry to a residential man of 'kurva' community for only Rs. 300 on 19-7-44. The causes of sale given in the deed were : to pay off the promissory note debt taken from a potter (resident of Rayadrug) and also for the expenses of the family. Another executant, a goldsmith belonging to the same village of Hosalli sold away on 17-4-46 his srotriyam land to a non-residential Lingayat ryot for Rs. 500, the area being about 132.05 acres (5.92 acres wet and 126.13 acres dry). The cause stated for the sale was payment of debt which consisted of : the total mortgage debt amount Rs. 235 and promissory note debt Rs. 169 and other miscellaneous borrowings amounting to Rs. 96 amounting for the total sum of Rs. 500. It may be noted that srotriyam or Inam lands are as a rule rated high on account of the concessional land revenue called Jodi or quit rent payable on Inam land to the Government. On the contrary, other things being equal, lands under the Zamindari estates are usually rated low due to want of survey and settlement

¹ During 1946 and 1947 for investigation in connection with my thesis.

operations of the areas in the estates, existence of joint pattas and difficulty of patta transfers apart from considerations of limited facilities of rural credit, irrigation and high rents.

There are also in addition other factors which may tend to raise or depress land prices like the situational advantages, special manuring, existence of fruit and other valuable trees, existence of a tank or a well, or some other additional irrigation facilities as easy command of supply of irrigation water at all times from the source, facilities for growth of second crop paddy (Dālwa) and the suitability of land for seed beds. Lands situated at a convenient distance of the adjoining villages or in vicinity of a road or town may be offered higher prices due to competition among ryots or proximity to markets. Similarly high prices may be paid for plots surrounded by fields of small ryots who are eager to consolidate or enlarge their holdings. Lands subjected to inundation by drainage canals or channels or open to the menace of crops being grazed away by the wild cattle in the nearby forests (e.g. Dewarapalem village in Nellore taluka) may be underrated. Sale values of land may be also depressed when there is a sort of combination among the villages prohibiting the members of the village from buying the lands of other members due to debt and other reasons or preventing an outsider from bidding for any land in the village or from cultivating it, if he is so bold as to buy it against the prevalent custom and feelings of the villagers. It is stated such practices are common among the "kallor" villages of South Madras where practically the whole village is inhabited by one community. But the last mentioned circumstance is a rare one.

Whenever land is purchased on other considerations such as amenities, prestige, aesthetic or other cultural or social values in addition to economic considerations, the price offered is likely to be higher than, if it were bought and sold purely as an economic proposition based on productive or earning power of land. Thus the price offered especially to a given urban site strictly speaking may be said to consist of the aggregate of productive, anticipated and amenity values.

The above discussion hardly leaves any space to emphasize the seriousness of the situation arising out of high land values and speculative tendencies in farm lands and building sites. The suggestion of payment of direct grants to the buyers to cushion the shock in case of a steep decline in prices in the near future may be ruled out. Other alternate ways of stabilisation of agricultural prices, the system of area allotments of cropping and even wholesale debt adjustments, if necessary, may be thought of. It may be expected that when prices decline, the chances of speculation in land will be less. But as the supply of desirable land is limited, even with the decline in prices the value of land may not decline to the same extent. Hence in order to discourage speculation in land a more direct measure of legal prohibition of land transactions for the purpose of speculation for private profit coupled with a levy of a specific tax as capital gains made out of sales effected within three years from the date of purchase may be resorted to. The law may also provide for keeping the prices of properties in a fixed relation to their value and output so as to prevent speculation in land. A highly radical suggestion would be no doubt the abolition of rights of private property in land by declaring that all land resources belong to the state and only the use of it may be invested in varied proportions in private individuals under vigilant social control,

THE NEW CONSTITUTION OF FRANCE

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THE salient features of the new Constitution are as follows¹ :—

Two chambers, the National Assembly and the Council of the Republic.

The National Assembly is elected by universal suffrage ; the Council by universal indirect suffrage.

Ministers are responsible only to the National Assembly.

The National Assembly votes the budget.

Members of the Council can propose bills to the National Assembly with the exception of laws which would involve increases in expenditure or reduction in revenue.

The President of the Republic is elected by both Houses for seven years. He chooses the Prime Minister.

The question of confidence can be put by the Prime Minister only. The vote is by public ballot and confidence can be refused by absolute majority only. Vote on a censure motion similarly is by public ballot and absolute majority.

If two ministries fall within 18 months, the Chamber can be dissolved by the Cabinet ; this provision is not applicable during the first 18 months.

The constitution of 1946 differs from that of 1875 in four significant ways. Firstly, the fundamental principles inspiring the constitutions have been clearly stated in the Preamble. Fundamental rights include the right to strike subject to laws, and the right to employment or subsistence. The right to property is not absolute ; certain forms of property are liable to be socialized. And by granting to women equal rights with men, the vote has been given to the former, a fact which may have incalculable effect on the future course of politics. Secondly, the constitution makes the lower Chamber sovereign for all essential purposes. The people exercise the sovereignty vested in them through their deputies in the National Assembly (Art. 3). The Council of the Republic has legislative initiative but is really a consultative body. Thirdly, the ministry has been given the power to dissolve the National Assembly after the first 18 months of its life. Under the constitution of 1875 the President of the Republic could dissolve the Chamber, with the approval of the Senate. Fourthly, the constitution requires that both the question of confidence and the motion of censure must be carried by absolute majority of the Assembly and the ministry in the event of adverse vote

¹ See Appendix for the draft of the Constitution.

is to resign collectively. The power of dissolution, and censure by absolute majority are important steps towards effective government. It is well known that the instrument of dissolution has greatly strengthened the hands of the cabinet in England and it may be expected to have the same effect in France.

The twin problem of French government has been, how to secure strong and durable cabinets and how to secure a stable parliamentary majority as a basis for the first. French political parties have been based on ideological differences, not upon a party platform. Consequently there have been too many of them. There is little party discipline. Unlike the English parties, a French political party did not under the Third Republic look forward to accepting responsibility for government and was not organised for that purpose. Each party merely hoped for a share in the government. The result was unstabled coalitions. If the nation decided to have large parties it could probably do so by returning only those parties which had a chance of power and large parties would certainly lead to greater stability of the Cabinets. Perhaps as Lowell thought Parliamentary government is unworkable except under a two-party system. To an outsider then the solution of the problem would seem to lie in consolidation of large parties and in particular of two large parties.

But this is not how the Frenchmen have looked at the problem themselves. They are quite satisfied with their ideas of representation and election. They are not accustomed to sacrifice political convictions to party discipline or practical exigencies; nor have they learnt to regard stable ministries as the supreme necessity. It would be an error to suppose that the constitution-makers of 1946 were actuated by the sole desire to provide for a stable government. There was a general realization that the parliamentary system of 1875 had somehow failed and had been partly responsible for the fall of France in 1940. Stability had to be given to the French Executive. But this consideration was soon obscured, as in 1871, by another, which party would benefit most by the new Constitution? The object became to frame the constitution in such a way as to place your political opponents at a disadvantage or to concede them as few advantages as possible. It cannot be quite denied that the major parties have shown a certain realism and made sacrifices. Thus the Communists have agreed to a second Chamber and MRP have compromised on the questions of the lay character of the Republic and of private property. Essentially the struggle in the Constituent Assembly lay between two systems of thought. The Right desired checks and balances including a second chamber and a President of the Republic having real powers, because it feared a proletarian dictatorship. The Left voted for a pure democracy in which the will of the people would be supreme. The Left feared de Gaulle whom it expected to be the first President. Either way a strong executive could not be achieved. If checks and balances, then the American deadlocks would recur; if pure democracy, then the futilities of the Third Republic would be repeated. Much eloquence was spent on elaborating a false contrast between genuine democracy and a Presidential form of government. The Communists denounced the latter. The realistic choice for Frenchmen lay as the *Economist* said (April 27, 1946) between a sovereign Government as in England or (following Rousseau) a sovereign Assembly. The British system, it said, was *de facto* an example of

sovereign Government because there the people elected a government by choosing a Prime Minister and a party and that government was supreme until the next election, Parliament acting as constant critic and watch-dog but normally not attempting to unseat the government. However, it was not possible to copy the British system entirely. A French executive cannot be trusted in view of past history with such immense powers as the British Cabinet enjoys subject to conventions. The issue of the long struggle in the Constituent Assembly has been that the Right has got the forms but the Left has scored real gains. The will of the people has been made supreme in the new Constitution to a greater extent than before. It is worth noting that the Communists were practically the only party which desired a strong executive, having in mind the immediate problems of France. And they also desired a sovereign Assembly which shows that fresh minds have been at work. The new constitution is a synthesis of these two desires.

Popular sovereignty has been safeguarded by Article 48 which makes the ministers responsible to the National Assembly only; by Art. 45 which requires that the Prime Minister before forming the Cabinet must be confirmed by an absolute majority of the Assembly; by Art. 13 which asserts that only the National Assembly votes upon the laws and cannot delegate this right; by Art. 17 under which only the members of the National Assembly have the initiative of expenditure; by the provision that the budget shall be brought before the National Assembly (Art. 16) and that a proposal by a member of the upper house having the aim of increasing the expenditure or reducing the income will not be admissible (Art. 14); by the institution of a Second Chamber vested with very limited powers of delay and advice (Art. 20); finally by Art. 38 which re-enacts the all essential provision that every act of the Chief of the State shall be countersigned by the Prime Minister and a minister. Under the constitution of 1875 the ministers were responsible to both Chambers but whether the Senate could force the ministry to resign was not clear. In fact, the Senate brought down several ministries, the recent cases being the Tardieu ministry, 1931; the Laval ministry, 1932; the Blum ministries, 1937 and 1938. As to budget and financial powers generally the lower Chamber had the virtual control of these matters even under the Third Republic. On the issue of Second Chamber the Left and the Right were sharply divided in the Constituent Assembly. The popular Republicans (Right) did not wish to revive the Senate while the Communists did not want a Second Chamber at all. The Right generally desired a Second Chamber to moderate the first, what M. Herriot called "a Chamber of Reflection." This was conceded by the Left after much struggle. But the new Second Chamber (the Council of the Republic) has such attenuated powers that it bears no resemblance to the old Senate. It does not vote on laws, it only offers advice and amendments which may be wholly or partly rejected by the Assembly. But it is provided that where the amendments have been voted by the Council by absolute majority, their rejection by the Assembly must also be by absolute majority. The point of practical importance is that the Council cannot delay its opinion for more than two months or a lesser period in cases thought to be urgent by the National Assembly. Under the new constitution, the Council is strictly a Second Chamber of advice. Its function is not to resist but to reflect. It is not a concurrent legislative authority at all because it does not vote upon laws and it is expressly provided (Art. 20) that if the Council fails

to give its opinion within the appointed time the law is promulgated in the form voted by the Assembly. In the context of large and organized parties now emerging in France, clash between the two chambers is unlikely. The *Times* Paris Correspondent wrote in November (The *Statesman*, Nov. 27, 1946): "The ancient and embittered opposition between the conservative Senate and the radical Chamber has disappeared; the Council is cast in the same mould as that of the Assembly and repeats necessarily the Assembly's frame work of party forces. Measures passed by the majority of the Assembly will be passed by the majority of the Council and criticisms likely to be levelled at this new style of Second Chamber will not be as with the Senate of old, that it was systematically obstructive but that it is systematically acquiescent."

Stable executive authority has been sought to be provided principally in two ways: firstly, by the requirements of absolute majority and public ballot for a motion of censure, and secondly, by the power of dissolution vested in the Cabinet. Art. 49 says that the question of confidence can be put only by the Prime Minister after deliberation with the Cabinet and the vote takes place by public ballot one full day after the question has been put. Confidence can be refused by absolute majority only. Art. 50 lays down similar conditions for a motion of censure. The vote takes place one full day after the motion has been put. The intention is to allow passions to cool and to prevent snap votes of confidence following an interpellation. The Constitution says nothing about the latter; nor did the Constitution of 1875. The cherished right of interpellation will of course remain. But since the new Constitution makes express provision for a motion of censure, interpellation will now be reduced to a simple question. The interpellation was essentially a clever manoeuvre by individual deputies to embarrass the ministry for which less scope will be found in the changed conditions.

The power of dissolution is given by Art. 51 which says that if two ministerial crises occur within 18 months, the National Assembly can be dissolved by the Cabinet after consulting its President. The constitution of 1875 vested the power of dissolution in the President of the Republic who had to take the approval of the Senate. This was a device of the monarchists who feared democracy. The manner in which the power was first used by President MacMahon discredited it. National sentiment has always regarded dissolution as a *coup d'état*. The purpose of Art. 51 is to fortify the authority of the Cabinet. French Cabinets of the Third Republic were extremely weak and defenceless in the face of an irresponsible and irremovable Chamber. Deputies had a free run of their appointed time. They criticised recklessly and brought up interpellations in which they risked nothing, the ministry everything. Sound policy was no guarantee that a ministry would survive. Survival depended upon the pleasure of the Deputies. Policy had to be often sacrificed to the needs of the moment. Waldeck-Rousseau, himself a Prime Minister, said (quoted by Finer) that the ministry's first duty was not to govern but to keep alive. It is not surprising that coherent government was impossible. Dissolution is the way by which a ministry can appeal to the country where it has strong convictions about its policy and encounters the opposition of the legislative. Prospect of dissolution has a salutary effect upon the discipline of both the Government and the opposition parties, for members dislike the expense and inconvenience of a general election. It puts them in a responsible and watchful

mood. With dissolution in the background, the attempt to pull down the ministry becomes a dangerous game to play. The deputies realize that they may have to answer to the country for their action. Both M. Tardieu in 1933 and M. Doumergue in 1934 proposed to invest the Cabinet with the power of dissolution, without success.

Dissolution has not the same significance under a two-party system and under a multi-party system. Under the first, as in England, dissolution follows a major defeat of the ministry in the Commons and precedes the general election. Under the English system of majority government the nation enthrones a Government in power with a specific mandate. The Government therefore has the right to appeal to the nation where it feels either that the mandate is exhausted or that it is impossible to carry it into effect owing to lack of confidence. In England the Government and the opposition are generally agreed as to the time and necessity of dissolution. At one time it appeared that the two-party system might be replaced by three parties and then dissolution became a complicated matter. What should be the guiding rule? Under a multi-party system, government is either a minority government or a coalition; it is usually the latter. In either case the government has no specific mandate from a majority of the electorate. Dissolution has not the same meaning here as under a two-party system but it is still useful as a way of resolving deadlocks which are likely to occur as between the parties. Dissolution in most cases is a way out of deadlock of some sort. Under a multi-party system dissolution is liable to abuse. The majority party in the coalition will decide the moment of dissolution and it may choose the opportunity to improve its position. Alternatively, the majority party may use the threat of dissolution to tighten its authority on other parties. To quote the *Economist*, "the power of dissolution placed in the Prime Minister's hands and applied to a coalition system is an important weapon of discipline given to the largest party in the coalition against its allies. (This) probably means a very great measure of power, not for the majority, nor even for the largest party in the majority but for the central caucus of the largest party in the majority."¹ The new constitution provides that the decision to dissolve the National Assembly shall be reached in the Cabinet after receiving the opinion of the President of the National Assembly and shall be decreed by the President of the Republic. These are important safeguards against a possible misuse of the power. Finally there is to be no dissolution during the first 18 months of the Assembly's life of 5 years.

The electoral law revives proportional representation based on a simple *scrutin de liste*. There is no second ballot. Each department normally represents one constituency. Voters must select one complete list but cannot cross out or add any name on it. They may however show their preference by altering the order in which the candidates are placed on the list. The seats are allotted among the lists according to the rule of the largest average. This average is calculated in the following way: the number of votes obtained by a list is divided by the number of seats already allotted to this list plus one. In this manner all the seats are successively allotted. The *French Weekly* (Nov. 9, 1946) gives the example of a hypothetical department electing 6 deputies where a list of five was received getting the largest number of votes.

¹ This comment was based on the first draft.

List	A.	57,000 votes
	B.	39,000
	C.	36,000
	D.	32,000
	E.	25,000

The average for the first seat is equal to the number of votes. It goes to A polling the largest average. But in allotting the second seat the average of A is $57,000 \div 2$, i.e., 28,500 votes only. The second seat goes to B and so on until all the seats have been allotted. If less than half the voters choosing a list change the order on the list, the order is left unchanged. Else, the candidate who has been put first most often is elected first.

In theory, PR should result in multiplication of parties but in France to-day political opinion and parties are crystalizing round two centres of attraction, the Communists and MRP. They represent real class divisions. The central fact of the French political scene at present is a well-organised Communist party and an anti-Communist opposition. The necessity of political survival would argue against too great a sub-division of the forces of the Right or the Left. Both the Communists and MRP owe their success at the polls to PR and neither party wants to give up the system.

Constitution may be revised in the following manner : a resolution specifying the particular object is first adopted by an absolute majority of the National Assembly. Then a bill is drafted and must pass both Chambers in the way of ordinary legislation. Later it is submitted to a referendum and promulgated by the President of the Republic. Under Art. 91 a Constitutional Committee presided over by the President examines whether any law which has been passed implies a revision of the constitution. One of the functions of the Committee is to settle differences between the two Chambers by compromise. No revision with respect to the Council of the Republic is to be made without the Council's agreement or recourse to referendum.

The long struggle over the Constitution may be briefly summarized. The Constituent Assembly first met in October 1945. The Communists had a slight majority. Next April a draft constitution was adopted by 309 votes to 249. The Socialists voted with the Communists against MRP. The draft constitution provided among other things a single Assembly and a President and a Prime Minister elected by the Assembly. It was the most thorough-going embodiment of popular sovereignty. Legislative, executive and even judicial power was concentrated in the Assembly. The draft was rejected by the nation on May 5. In the elections of June the nation showed its sense by returning MRP with a small majority of 15 over the Communists. Nevertheless the Communists had increased their total poll. The new Constituent Assembly had to revise the constitutional draft. During the following months, battle raged over two of the key provisions in the Coste-Floret project (the new draft reported by M. Coste-Floret MRP). These were : (1) the second chamber has the right to initiate legislation and to object to laws passed by the Assembly, (2) the President is elected for 7 years by both the Chambers ; he should have larger authority. In Committee, these essential clauses were carried by an MRP-Socialist majority against a

Communist minority. The constitution was finally adopted on September 29 after several compromises. The nation ratified it on October 13, 1946. The compromises show that the Communists have conceded the forms only. The President has much the same legal powers as under the Constitution of 1875 but in practice he may have greater authority than before because that is the general desire. In the referendum of October 1945 72% of the electorate voted in favour of greater powers for the President and the Cabinet in relation to the Assembly. The Right demanded that the President should be elected by direct vote as in America, to counterbalance the Assembly. But this is a French anathema, and it is well that the French did not copy the American System at a time when their greatest need is effective and continuous government. Another demand of the Right was that private property should be protected not by laws which may change but by the constitution.⁶ The Preamble of the new Constitution reiterates the Rights of 1789 which included the right to property. But as shown, this right is not absolute.

A word may be said about the parties. There are three major parties, the Communists, MRP (Mouvement Re'publicain Populaire) and the Socialists; and two minor ones, the Radical Socialists; and PRL (Parti Re'publicain de la Liberté). Their relative strength in the National Assembly elected last November is as follows:—

Communists	186
MRP	163
Socialists	96
PRL and Allies	87
Radicals	63

The Radical Socialists, the largest party in the Third Republic was a party of the petit bourgeois and the better off peasant. It was a party of negation essentially; its chief purpose was to be left alone by the government and to reduce taxes. The party has lost ground. PRL is extreme Right and strongly anti-Communist. MRP is a new party of progressive Catholics supported by all that France which is Catholic at heart and by the Catholic trade unions. Like the Communists, MRP had a leading share in the Resistance and enjoys the consequent prestige. The Socialists are at the same time anti-clerical and anti-Communist. They are supported by the Socialist trade unions comprising the "white collar" trades, the civil servants, the bank clerks, the postal workers, etc. The Socialist weakness is a certain vagueness alike of policy and conception, yet the party as mediator between MRP and the Communists has great potential use. The future depends on the Communists in many ways. They are the only party which does not have a negative role, is not dominated by fear of political opponents, and has a clear-sighted policy. The Communist party is superior to others in backing, in devotion, in organization. Trade unions are predominantly Communist, and the peasant who used to vote Right or Centre in the past now votes Communist. Workers organized in both CGT and CGA are loyal to the Communist Party. To the common people the Communists represent the promise of a better future. Leaders of the party have shown great practicality and considerable willingness to compromise. The French Communists are not a fifth column as Mr. Churchill has often advertised them to be. "French Communism

is as far removed from Bolshevism as Paris is from Moscow." (The *Economist*, Nov. 23, 1946). The object of the party is to achieve Socialism by parliamentary means ; its avowed policy is to work in harmony with other parties in the interest of France. No other party has such a vivid perception of the needs of France, both immediate and long-term. The *Economist* observes (*loc. cit.*) that while the Socialists have indulged in humanistic phrase-making, the Communists have shown greater realism and have produced sound policy. The position to-day is that France will not let the Communists rule alone and no government can function without the Communists. Realizing this the Communist party has shown a spirit of conciliation especially towards the moderate Right. It has foregone premiership which was its due and which the Right denied it unjustly. The danger to parliamentary government at the moment is more from the extreme Right than from the Communists.

APPENDIX

The Constitutional Project adopted by the National Constituent Assembly on September 29, 1946.

(Note : Below is given a verbatim translation of the most relevant chapters of the Constitution. The omitted chapters deal with the following subjects :—Chapter IV, Diplomatic Treaties ; Chapter VII, Penal Responsibility of the Ministers ; Chapter VIII, The French Union ; Chapter IX, Superior Council of the Magistracy ; Chapter X, Territorial Collectivities ; Chapter XII, Transitory Arrangements. No article has been omitted from the Chapters rendered.)

PREAMBLE

On the morrow of the victory won by the free peoples over the Governments which attempted to enslave and degrade human personality, the French people proclaim anew that every human being, without distinction of race, religion or belief, possesses sacred and inalienable rights. They reaffirm solemnly the rights and liberties of man and citizen consecrated by the Declaration of Rights of 1789 and the fundamental principles recognised by the laws of the Republic.

They proclaim moreover as particularly necessary for our times, the social, economic and political principles as under :—

The law guarantees to woman in all the domains, rights equal to those of man.

Any man persecuted for his action in the cause of liberty has the right of sanctuary within the territories of the Republic.

Every one has the duty to work and the right to obtain employment. None shall be injured in his work or occupation, on account of his birth, his opinions or his belief.

Every man may defend his rights and interests through trade union action and follow the trade union of his choice.

The right to strike is exercised within the frame-work of the laws which regulate it.

Every worker participates through his delegates in the collective determination of the conditions of work as well as the management of the firm.

Every article and every firm the exploitation of which has or acquires the marks of a national public service or a monopoly in fact must become collective property.

The nation assures to the individual and to the family the necessary conditions for their development.

The law guarantees to all notably to the child, to the mother and to the aged worker, the protection of health, material security, rest and leisure. All human beings who on account of their age, their physical or mental condition or their economic situation find themselves unable to work have the right to obtain from the community suitable means of existence.

The nation proclaims the solidarity and equality of all Frenchmen in the responsibilities resulting from national calamities.

The nation guarantees to the child and to the adult, equal access to education, to professional training and to culture. The provision of education at all stages is a duty of the State.

The French Republic, loyal to its traditions, follows the rules of international public law. She will not engage in any war of conquest nor at any time use her forces against the liberties of any people.

Subject to reciprocity, France agrees to limitations of sovereignty necessary for the organisation and defence of peace.

France forms a union with the peoples overseas, based on equality of rights and duties without distinction of race or religion.

The French Union is composed of the nations and peoples who bring together and co-ordinate their resources and their efforts in order to develop their respective civilisations, to increase their well-being and to assure their security.

Loyal to her traditional mission, France intends to conduct those peoples who are in her charge, to the liberty to administer themselves and to manage their affairs democratically ; eschewing all systems of colonisation based on despotic rule, she guarantees to all equal access to public functions and to the individual and collective exercise of the rights and liberties proclaimed and affirmed above.

CHAPTER I

SOVEREIGNTY

Art. 1. France is an indivisible, lay, democratic and social republic.

Art. 2. The national emblem is the tricolour flag, blue, white and red with three vertical bands of equal dimensions.

The national anthem is the Marseillaise.

The Republic's motto is : "Liberty, Equality, Fraternity."

The Republic's principle is : Government of the people, for the people and by the people.

Art. 3. National sovereignty belongs to the French people.

No section of the people and no individual can assume its exercise.

The people exercise it, in constitutional matters through the vote of their representatives and through the referendum. In all other matters, they exercise it through their deputies in the National Assembly elected by a suffrage which is universal, equal, direct and secret.

Art. 4. All adults of both sexes, enjoying civil and political rights, who are French nationals or under French jurisdiction are electors under conditions determined by the law.

CHAPTER II

PARLIAMENT

Art. 5. The Parliament consists of the National Assembly and the Council of the Republic.

Art. 6. The duration of powers of each assembly, the mode of election, the conditions of eligibility and the rules of ineligibility and incompatibility are determined by the law.

The two Chambers are elected on a territorial basis, the National Assembly by direct universal suffrage, the Council of the Republic by the communal and departmental collectivities on universal indirect suffrage. The Council is renewed by one half (every three years).

However, the National Assembly may elect, by proportional representation, Councillors not exceeding one-sixth of the total number of the Council of the Republic.

The number of the members of the Council of the Republic cannot be less than 250 nor more than 320.

Art. 7. War cannot be declared without a vote of the National Assembly and the previous advice of the Council of the Republic.

Art. 8. Each one of the two Chambers is the judge of the eligibility of its members and of the regularity of their election. It alone can receive their resignation.

Art. 9. The National Assembly meets in full right for its annual session on the second Tuesday of January.

The total duration of the interruptions of the session cannot exceed four months. Adjournments of the session for more than ten days are considered as interruptions.

The Council of the Republic sits at the same time as the National Assembly.

Art. 10. The sittings of the two Chambers are public. The detailed accounts of the proceedings as well as the parliamentary documents are published in the *Journal Officiel*. Each Chamber can form itself into a secret committee.

Art. 11. Each Chamber elects its Bureau (President, Vice-Presidents, Secretaries and Questors) at the beginning of the session every year, by proportional representation of the groups.

When the two Chambers jointly meet for the election of the President of the Republic, their Bureau is that of the National Assembly.

Art. 12. When the National Assembly is not sitting, its Bureau controlling the Cabinet's actions may summon Parliament. It must do so on a demand made by one-third of the deputies or at the request of the Prime Minister.

Art. 13. The National Assembly alone votes upon the laws. It cannot delegate this right.

Art. 14. The Prime Minister and the members of the Parliament have the initiative of legislation. Government bills and private bills formulated by the members of the National Assembly are to be laid on the table of the latter. Private Bills formulated by the members of the Council of the Republic are laid on the table of the Council and transmitted without debate to the National Assembly. They are not admissible when they entail a reduction of the receipts or a creation of (new) expenses.

Art. 15. The National Assembly studies the bills which are brought before it in committees of which it determines the number, the composition and the competence.

Art. 16. The budget is submitted to the National Assembly. This law will comprehend only the strictly financial dispositions.

An organic law shall regulate the mode of presenting the budget.

Art. 17. The members of the National Assembly have the initiative of expenditure.

However, no private bills tending to increase the existing expenditure or to create new expenditure shall be introduced when the budget for provisional and supplementary credits is being discussed.

Art. 18. The National Assembly regulates the accounts of the nation.

For this purpose, it is assisted by the Court of Accounts. The National Assembly may entrust the Court of Accounts with all inquiries and studies relative to the execution of public revenues and expenditure or to the management of the Treasury.

Art. 19. Amnesty can be granted only by a law.

Art. 20. The Council of the Republic examines, for advice, bills passed in first reading by the National Assembly. In the case of the budget this period is shortened when necessary so as not to exceed the time utilised by the National Assembly for its discussion and voting. When the National Assembly has decided upon an urgent procedure, the Council of the Republic gives its opinion within the same period as that provided for discussion in the National Assembly by regulation of the latter. The periods envisaged by the present articles are not counted during the interruptions of the session. They may be prolonged by the decision of the National Assembly.

If the opinion of the Council of the Republic is the same or if it has not been given during the periods prescribed in the preceding paragraph, the law is promulgated in the form voted by the National Assembly.

If the opinion is not the same, the National Assembly examines the bill during the second reading. It gives a definitive and sovereign decision upon the amendments proposed by the Council of the Republic, either accepting or rejecting them, wholly or partly. In the case of total or partial rejection of these amendments, the vote during the second reading of the law takes place by public ballot by an absolute majority of the members composing the National Assembly, when the vote upon the whole law has been expressed by the Council of the Republic under the same conditions.

Art. 21. No member of the Parliament may be prosecuted, searched, arrested, detained or judged on account of the opinions or votes expressed by him in the exercise of his functions.

Art. 22. No member of the Parliament may, during his mandate, be prosecuted or arrested in criminal or corrective matters without the authority of the Chamber of which he is a member except when caught in the act. The detention or prosecution of a member of the Parliament is suspended if the Chamber of which he is a member requires it.

Art. 23. The members of the Parliament receive an allowance fixed in relation to the salary of a class of officials.

Art. 24. No one can be a member of the National Assembly and the Council of the Republic at the same time.

The members of the Parliament cannot belong to the Economic Council or the Assembly of the French Union.

CHAPTER III

THE ECONOMIC COUNCIL

Art. 25. An Economic Council the status of which is determined by law examines for giving opinion those bills which fall within its competence. The bills are submitted to it by the National Assembly before the latter deliberates upon them.

The Economic Council may be consulted by the Cabinet. It must be so consulted for the establishment of a national economic plan having the objects of full employment and rational utilisation of material resources.

CHAPTER V

THE PRESIDENT OF THE REPUBLIC

Art. 29. The President of the Republic is elected by the Parliament. He is elected for seven years. He is re-eligible only once.

Art. 30. The President of the Republic nominates in the Council of Ministers, the Councillors of State, the Grand Chancellor of the Legion of Honour, ambassadors and special envoys, members of the Superior

Council, members of the Committee of National Defence, Rectors of Universities, Prefects, Heads of the central administrations, general officers, and government representatives in the overseas territories.

Art. 31. The President of the Republic is kept informed of international negotiations. He signs and ratifies treaties.

The President of the Republic accredits ambassadors and special envoys to the foreign powers. The ambassadors and the special envoys of the foreign powers are accredited to him.

Art. 32. The President of the Republic presides over the Council of Ministers. He causes the minutes of the proceedings to be taken, and preserves them.

Art. 33. The President of the Republic presides with the same powers over the Superior Council and the Committee of National Defence and assumes the title of the Chief of the Armies.

Art. 34. The President of the Republic presides over the Superior Council of the Magistracy.

Art. 35. The President of the Republic in the Superior Council of the Magistracy exercises the right of pardon.

Art. 36. The President of the Republic promulgates the laws within ten days which follow the transmission to the government of a law definitely adopted. This period is reduced to five days in case of urgency so declared by the National Assembly.

Within the period fixed for promulgation, the President may, by a message with reasons assigned, request the Chambers to reconsider the law; this request cannot be refused.

In default of promulgation by the President of the Republic within the period fixed by the present constitution, the promulgation shall be made by the President of the National Assembly.

Art. 37. The President of the Republic communicates with the Parliament by messages addressed to the National Assembly.

Art. 38. Every act of the President of the Republic must be countersigned by the Prime Minister and a Minister.

Art. 39. Within thirty days at the most, within fifteen days at the least before the expiry of the powers of the President of the Republic, the Parliament proceeds to the election of a new President.

Art. 40. If in virtue of the preceding article the election must take place during a period when the National Assembly has been dissolved according to Art. 51, the powers of the existing President of the Republic are prolonged until the election of a new President. The Parliament proceeds to the election of a new President within ten days of the election of the new National Assembly.

In the above case, the nomination of the Prime Minister takes place within fifteen days following the election of the new President.

Art. 41. In the case of a hindrance duly ascertained by a vote of the Parliament or in the case of vacancy through death, resignation or any other cause, the President of the National Assembly provisionally assumes the functions of the President of the Republic. He shall be replaced in his duties by a Vice-President.

The new President of the Republic is elected within ten days excepting what has been said in the preceding article.

Art. 42. The President of the Republic is only responsible in the case of high treason.

Art. 43. The office of the President of the Republic is incompatible with any other public function.

Art. 44. Members of the families which have ruled over France before are not eligible for the Presidency of the Republic.

CHAPTER VI

THE COUNCIL OF MINISTERS (THE CABINET)

Art. 45. At the beginning of each legislature, the President of the Republic after the usual consultations appoints the president of the Council (*i. e.*, the Prime Minister).

The Prime Minister submits to the National Assembly the programme and the policy of the Cabinet which he proposed to form.

The Prime Minister and the ministers can be appointed only after the Prime Minister has been invested with the confidence of the National Assembly by public ballot, by an absolute majority of the deputies except when the National Assembly is prevented by force from meeting.

The same is true during the life of a legislature in the event of vacancy created by death, resignation or any other cause except what is said below in Art. 52.

A ministerial crisis supervening within fifteen days of the appointment of the ministers is not taken into account for the purposes of Art. 51.

Art. 46. The Prime Minister and the ministers chosen by him are appointed by decree of the President of the Republic.

Art. 47. The Prime Minister secures the execution of the laws.

He makes all civil and military appointments except those covered by Articles 30, 46 and 81.

The Prime Minister secures the direction of the armed forces and co-ordinates the operations of national defence.

The acts of the Prime Minister envisaged by the present article are countersigned by the ministers concerned.

Art. 48. The ministers are collectively responsible before the National Assembly for the general policy of the Cabinet and individually for their personal acts.

They are not responsible to the Council of the Republic.

Art. 49. The question of confidence can be put only after deliberation in the Cabinet. It can be put only by the Prime Minister.

The vote on the question of confidence can take place only one full day after it has been put to the Assembly. It takes place by public ballot.

Confidence can be refused to the Cabinet only by an absolute majority of the deputies of the Assembly.

This refusal entails collective resignation of the Cabinet.

Art. 50. A vote of censure passed by the National Assembly entails collective resignation of the Cabinet.

The vote can take place only one full day after the motion has been put. It takes place by public ballot.

A motion of censure can be adopted only by an absolute majority of the deputies of the Assembly.

Art. 51. If in the course of one and the same period of eighteen months two ministerial crises intervene under the conditions envisaged by Articles 49 and 50, the dissolution of the National Assembly may be decided in the Cabinet, after consultation with the President of the Assembly. The dissolution shall be pronounced according to this decision by a decree of the President of the Republic.

The provisions of the preceding paragraph are not applicable to the first eighteen months of (the life of) the Legislature.

Art. 52. In the event of dissolution, the Cabinet with the exception of the Prime Minister and the Minister of the Interior remains in office to deal with current business.

The President of the Republic appoints the President of the National Assembly as Prime Minister. The latter nominates the new Minister of the Interior in agreement with the Bureau of the National Assembly. He appoints as ministers of State, members of those groups which were not represented in the Government.

The general election takes place twenty days at the least, thirty days at the most after the dissolution.

The National Assembly meets in full right on the third Thursday which follows the election.

Art. 53. The Ministers have access to both the Chambers and to their committees. They must be heard when they request it.

They may be assisted in the discussions in the Chambers by commissioners appointed by warrant.

Art. 54. The Prime Minister may delegate his powers to a minister.

Art. 55. In the case of vacancy due to death or any other cause, the Cabinet charges one of its members with the provisional exercise of the functions of the Prime Minister.

CHAPTER XI

THE REVISION OF THE CONSTITUTION

Art. 90. Revision takes place in the following manner :

Revision must be decided upon by a resolution passed by an absolute majority of the members constituting the National Assembly.

The resolution specifies the object of the revision.

It is submitted, within a minimum period of three months, to a second reading, which must take place in the same manner as the first, unless the Council of the Republic urgently called upon by the National Assembly has adopted the same resolution by absolute majority.

After this second reading the National Assembly drafts a bill concerning the revision of the constitution. This bill is put before Parliament and adopted by majority and in the manner provided for ordinary legislation.

It is submitted to referendum, except when it has been adopted in second reading by the National Assembly by a majority of two-thirds or has been voted by a majority of three-fifths by each of the two assemblies.

The enactment is promulgated as constitutional law by the President of the Republic within eight days of its being adopted.

No constitutional revision relating to the existence of the Council of the Republic may be effected without its agreement or recourse to the procedure of the referendum.

Art. 91. The Constitutional Committee is presided over by the President of the Republic.

It includes the President of the National Assembly, the President of the Council of the Republic, seven members elected by the National Assembly at the beginning of each annual session by proportional representation of its groups and chosen outside its members, three members elected in the same manner by the Council of the Republic.

The Constitutional Committee examines whether the laws passed by the National Assembly pre-suppose a revision of the constitution or not.

Art. 92. Within the time limit for the promulgation of the law, the Committee is put in cognizance of a demand issuing jointly from the President of the Republic and the President of the Council of the Republic, the Council having decided by an absolute majority of the members constituting it.

The Committee studies the law, endeavours to bring in accord the National Assembly and the Council of the Republic and, in case it does not succeed, decides within five days of its having been informed.

This period is limited to two days in case of urgency.

The Committee is only competent to decide upon the possibility of revision of the dispositions of titles I to X of the present Constitution.

Art. 93. The law which, in the opinion of the Committee, implies a revision of the Constitution, is sent back to the National Assembly for fresh deliberation.

In case Parliament maintain their first vote, the law cannot be promulgated before the Constitution has been revised in the manner envisaged by Article 90.

If the law is found in accordance with the dispositions of the chapters I to X of the present Constitution, it is promulgated within the time provided by Article 92.

Art. 94. In case the whole or part of the Metropolitan Territory is occupied by foreign armies, no procedure for revision can be started or continued.

Art. 95. The Republican form of the Government cannot become the object of a proposal of revision.

What of the future? A new constitution by itself cannot supply political stability though it may help. Political stability must be sought not in the institutions but in the spirit of working them. Since the brief unity of the Resistance has long vanished national unity must find a new basis in mutual compromise and better parliamentary and public manners, for as Dr. Finer has recently observed, "Manners maketh Parliaments." One can give endless advice to the French concerning how to conduct their Government but it does not seem necessary to give it to so intelligent a people. The encouraging signs for the future are the emergence of large and organized parties and a frame of the national mind which is conducive to positive action.

DWĀRKĀ IMAGE OF RAṆACHHODJĪ AND THE TEMPLE AT DĀKORE

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THE two prominent places of Kṛṣṇa worship in Western India are Dwārkā and Dākore. The one of Tulasī-Śyāma in the Gir forests in Kāthiāwār and the other of Śyāmālāji in the eastern forests round about Idār state territory are also noteworthy. However, the places of Dwārkā and Dākore are more intimately connected by tradition on account of the images installed and the temples built for them.

Dwārkā or Dwārāvati is a city of hoary antiquity. When Śrīkṛṣṇa had to flee from Mathurā, being chased by Jarāsandha, infuriated by the death of his maternal uncle Kāṇsa, he came to Saurāṣṭra and founded Dwārkā "the doors to the ocean." When actually this event occurred it can tentatively be assigned a date contemporaneous with that of the Mahābhārata war. Any way, it must have been earlier than the 3rd century B.C. the time of the present "Mahābhārata."

The legend of the original site of Dwārkā being engulfed in an oceanic inundation appears to be true for various reasons; and that is the main reason why several localities advance claim to be the site of the original Dwārkā. It is said that Kṛṣṇa built a fort of solid gold, now submerged. The chief village Jagat on the sea-shore has a temple of Vikrama Nārāyaṇa situated on the river Gomatī, which issuing from the ground of Okha flows through Jagat and thence into the ocean—the place of confluence being called Cakra Tirtha. Purāṇas record that Kṛṣṇa was succeeded by his great-grand-son Vajranābha, who, it is said, built the present temple of Dwārkānāth, called also "Trilokasuṇḍara" on the north bank of the Gomatī creek.

In later times, Dwārkā proved to be a very popular pilgrim-centre to the west of India. It is believed that the great Śankarācārya made Dwārkā in farther west as his outpost, calling it "Śārādā Pīṭha" about the 8th century A.D. Dwārkā is one of the four prominent "dhāmas" of pilgrimage where Hindus from all parts of India flock, and is included in the list of seven "cities" giving liberation (muktīpuri).

Modern Dwārkā, it seems, was not a popular centre of pilgrimage in early times. No grants are discovered, awarding lands or villages to the Dwārkā shrines. Were it a famous, flourishing and opulent seat of worship, it would not certainly have escaped the kind attentions of Mahomedan conquerors like Mahmud Gazni, Alafkhān and others. As it is, the city has not suffered from Mahomedan vandalism.

The modern temple of Jagat (short for "Jagan Nārāyaṇa") near the Beṭa Śaṅkhoddhāra appears to have been built on the plinth of an older structure; because it is known that when Mahmud Beḡaḍā con-

quered Dwārkā in 1473 A. D. "it was given up to plunder, its buildings were razed, its temples destroyed, and the idols broken to pieces."*

It is recorded in tradition that in Samvat 1212 (1156 A. D.) the old and genuine image of Dwārkādhiṣa Śrīkṛṣṇa was removed from the coast-line and brought to an interior place in Central Gujarāt, probably to protect the image from pollution, desecration or destruction at the hands of hostile religious zealots. This sort of device to remove precious treasures of religious and cultural values to safe resorts during unsettled times was in vogue among Jains in the mediaeval period and even among our own times during the last world-war when valuable art-treasures of several Indian museums were removed to many out-of-the-way places of general safety. This is, however, a secular explanation of a great event, which is believed to have occurred in Samvat 1212.*

We have the traditional history of the incident recorded both in history and in Sanskrit Purāṇa—like "Māhātmya" works, such as the "Daikapur Māhātmya," which mentions the date of the event as under, i.e. Samvat 1212:—

“वत्सरे विक्रमार्कस्य नेत्रेन्दुक्षिरामिते ।
कर्तृक्यां ब्रह्मनक्षत्रे प्रत्युप गुरुवासरे ॥
डंकग्रामं समायातो भगवान् द्वारकेश्वरः ।
कृणुछोड इति ख्यातिं तत्रागत्य च लब्धवान् ॥” अ. ४

The entire incident has been effectively told in the following verses:—

। कुंडलिया छन्द ।

“देवदिवाली दिनको, संवत बारावार ।
पुरीद्वारका जायके, ग्रहि लायो मोरार ॥
ग्रहि लायो मोरार, डंकपुर डंका दीना ।
धन्य बोडाणा भक्त, नाथकु बस कर लीना ॥
धनधन गुजरेदेश, देशमे भइ खुशाली ।
जय जय श्री रणछोड, पधारे देव दिवाली ॥१॥

हरन हरिका देखके, भये विकल सब लोक ।
पीछे धाये गूगली, उरमे पुरन शोक ॥
उरमे पुरन शोक, हुँडते डाकोर आये ।
प्रभु आग्याको पाय, नाथकु नीर छुपाये ॥
तुला भइ जब तीर, घाट तब घड्या अरिका ।
लालच दे लपटाय, भुलाये हरन हरिका ॥२॥

चरनशरनकी लाजसे, पुरन कीनो कोड ।
सवा वालकी नथ्यसे, रण छोड्यो रणछोड ॥
रण छोड्यो रणछोड, देशमे डंका दीना ।
भक्ताधीन भगवान्, मनोरथ पुरन कीना ॥
ध्वजादंडके स्थान, छुपाये अशरणशरण ।
ताके पूजन काज, पधराये पादुचरण ॥३॥”

These Hindi verses are inscribed on a stone in the Gomati tank at the place where the image of Ranachhodjī was kept hidden for twelve days and where an arrow was shot by a Gughali lad who had chased the idol that was being removed by one Vajesingh Boḍāno. At this spot are instituted the foot-prints of the Lord and a flag, commemorating the event.

The tradition about Dwārkā image having been brought to Dākore by a staunch devotee is comparable to a similar tradition regarding the installation of the image of Viṭhobā (Viṭhala from "Viṭthu," the Kannaḍa for Viṣṇu + la, a suffix) in Mahārāstra at Paṇḍharpur at the hands of saint Pūṇḍalika, who is said to have brought the image either from Dwārkā or from Mathurā some time about 1287 Samvat.

*The report about "Ranachhod Temple" available in the "Supplement" to "Mirāt-i-Ahmedi" (Ch. III) which describes the various temples and Tīrthas sacred to the Hindus, appears to be fairly anterior to the building of the present temple by Tāmbyekar, popularly called "Tāmbekar." Ali Muhammad Khān, the author of M.-I.-A. was the chief Reporter in the Province of Gujarāt, who was eventually made Diwān of the Province in 1747 A. D. and was the last of the Moghul Diwāns of Gujarāt, which was then conquered by the Marāṭhā force of the Peśvā and Dāmājirāo Gāekwād. It was in 1755 A. D. that Ahmedabād was finally taken by these Southern invaders. The chronicle of "Mirāt-i-Ahmedi" was completed about the time that Dāmājī joined the great Marāṭhā army and took a creditable part in the disastrous battle of Pānīpat (January 1761). The historian has put on record the statistical and other information which his diligent search,—with the help of his Hindu assistant Miṭhālāl,—had brought to light. The compilation appears to have taken about ten years (1750 to 1760).

This record which is prior to the building of the present temple in 1772 A. D. definitely refers to the one built by Abhesingh, the viceroy of Gujarāt under Emperor Mahummadshāh and for which he had managed to secure the grant of Dākore village for the maintenance of the Viṣṇu temple. An official copy from the "Record of Rights" maintained in Thāsra Māmlatdār's office regarding lands in Dākore village is given below for reference. § It alludes to the tradition of Boḍānā

§ तालुके ठासरानी कलमबंधीमांथी: डाकोर संबंधीनो उतारो.

नंबर	गामनुं नाम	इनामी गामो गाम जानार	शा दावा उपर खाय छे ?	परठण गाम आखानी	बीना, सरकार जाहेर करवाना.
१	मोने डाकोर	श्री रणछोड रायजी महाराज	असल पादशाही बाराधी तथा राजाओ मार-वाडीना नखतथी देवमा खर्चमा आपेलुं छे अने खरीदपत्रो घणा छे.	खाबापुं छे देवना खर्चमा	आ धणी खानार देवना खर्चमा उपज जाय छे: वास्ते कोई दिवस सरकार आवे एवुं नथी.

I am obliged to Mr. Amritlāl N. Bhatt, B.A., LL.B., Manager, Dākore temple (in July 1942) for this copy and the copies from High Court judgments re: the suit for Trusteeship and management of the Dākore temple.

having brought the image from Dwārkā. It lends some authenticity to the legend in the Sanskrit "Daṅka Purāṇa," which is supposed to have been composed under the patronage and inspiration of Gopāla Nāik Tāmbvekar. The version of the Mirāt-i-Ahmedi† is, therefore, quoted below in full :—

"Rañchhod Temple.—In Thāsrā, thirty 'kos' from the city, is a temple which has an idol of Rañchhod, one of the names of Kṛṣṇa. This is how it left Dwārkā, its original site. A certain devotee of Kṛṣṇa named Bodhāṇā, of the tribe of Gugliś, went to Dwārkā.

Raṅchhod appeared to him in a vision and said "Take me home with thee." "How can I remove thee from this place? the priests and guards would not permit it," replied the devotee. "I shall make myself lighter. Thus thou must remove me. And fear not, for thou shalt be unseen by mortals." The devotee took the idol as directed and reached Dākore, his home, where it was set up and worshipped publicly.

"Now the idol remained visible to the priests at Dwārkā until the day of the devotee's safe entry at Dākore. When the news of public service at Dākore reached the priests, they sent a party to fetch the idol, for they had lost their means of livelihood. The devotee, through fear or being pre-warned by the god, threw the idol into the tank. The party searched in every nook and corner of the town, but in vain. They then entered the tank, and with the point of their lances began to feel in the water. Of a sudden something was struck, and soon the tank was full of blood, which is still to be seen.

"A fight for the possession of it then ensued; but in the end it was decided to hand over the idol to whomsoever would give a lump of gold equal to the weight of the idol. The poor devotee lost all hope, but it so happened that the scales turned against the Dwārkā party, for no amount of gold could weigh as much as the idol. Then Bōdhāṇā, the Gugli, as bidden in a vision, put his wife's nose-ring with some leaves of 'Tulsi' in the scale, and lo! the idol was weighed.

"The party then left for Dwārkā lamenting the loss, but the god consoled them by pointing out another idol in the river Gomati at Dwārkā. It was taken out and placed in the vacant place.

"This happened in 1212 of the Vikrama Era, about 600 years before the completion of this book (Mirāt-i-Ahmedi) i.e., in the Vikram year 1817.

"The idol is clad in fine clothes with precious jewels. Large crowds of worshippers from far and near assemble with offerings in the month of Āśvin on the full-moon day."

The removal of the image from Dwārkā and bringing to Dākore by Vajesingh was looked upon very critically by the people of Dākore village, who tried to interpret the event as it suited their intellect and fancy. Some argued, "Who can dare remove Dwārkeśa from the temple which is so well protected by brave guards of the king?" Others questioned the authenticity of the incident as it could not have been accomplished in

† *Vide* The English Translation of "Supplement to Mirāt-i-Ahmedi in Persian," by Syed Nawāb Ali and C. N. Seddon (G. O. Series 1924), pp. 144-45.

so short a time with the help of old and infirm bullocks. Some said, "Who knows? Vajesingh might have brought this image exactly identical with the one at Dwarkā from some Vaiṣṇava devotee, or by perpetrating theft† somewhere." Some two or three, however, concluded by saying, "What have we to do with all that? Any way, we are glad; the image is very elegant and worth looking at!"

The 'Dānpur Māhātmya' refers to the previous birth of Vijayasingh to explain his devotion in mortal life. It is stated in the 'Bhāgavata', that Devakī and Vasudeva had, in a previous state of existence by their prayers and piety, succeeded in securing a promise (varadāna) from Viṣṇu that he would be born as their son; while Yaśodā and her husband had likewise secured a promise from Him that he would give them the happiness of fondling Him as their own child. Viṣṇu was, therefore, born as Kṛṣṇa at Mathurā to Devakī and taken secretly by his father to Nānda a relation at Gokula, as his life was in danger, King Kāṁsa having heard a prophecy that this son of Devakī would kill him. Kṛṣṇa having fulfilled his double promise, entered upon his own peculiar function as 'Avatāra' described in the Bhagavad-Gītā. Here, then, we have the first remarkable tenet of the Vaiṣṇavas; a belief in a compassionate living power, ready to be born in flesh and blood at the request of pious and affectionate devotees. All the merry-making and mischief ascribed to Kṛṣṇa, while being at Gokula is thus explained to have been a part of the programme gone through according to the previous promise, for the purpose of pleasing and teasing Yaśodā and Nānda, the Divine child, well knowing that human parents love that child the best, who torments them the most and costs them the greatest anxiety or grief. It is this idea which pervades the whole of the vast mass of poetry which has gathered round the achievements of Gopāla Lālaji, the name of Kṛṣṇa in his boyhood. While Kṛṣṇa was doing his Bālalīlā (childish sports) at Gokula he had given a 'varadāna' (promise) to one Vijayanāndana who longed to see him every day, that in another stage of life his longing would be satisfied.

This Vijayanāndana and his wife are supposed to have been born at Dākore as Vijesingh (alias Rāmadās or Boḍāṇā) and Gaṅgā in Rajput families. Vijesing married Gaṅgā; and the couple were staunch devotees of Kṛṣṇa. Vijesing had once asked a Brāhmin, "How can I please God?" The Brāhmin had replied "Śrī Rāṇchhodjī is God's incarnation. Even women, Sūdras and Bhils please him by 'bhakti' (devotion); he loves Tulasi (sweet basil) more than anything else." Vijesing, therefore used to plant tulasi in his hand and go twice every year to Dwarkā and offer it to Rāṇchhodjī. Vijesing is alleged in the 'Dānpur Māhātmya' to have continued this practice for 60 years. The legend about the tulasi plant is a long one, but it finds its popular version in the following four lines taken from a popular Gujarātī 'Garbā':--

"Oh my mother Tulasi! I ask you,
Who is your mother and who is your father?"
"My mother is the earth, my father is the sky,
Devakī is my mother-in-law, and Kṛṣṇa is my husband."

† "उद्धोषो नगरे जातः केनापि द्वारकेश्वरः ।
रात्रौ मंदिरतो नीतश्चौयेषेति प्रतिग्रहं ॥" अ. ५, श्लो. ५

The steadfastness of Boḍāṇā's faith and these constant Tulasi offerings pleased Rañchhodji, and when the old man came in his 80th year, with his usual present, the God told him "I know the secret of your mind, you love me, and want to worship me very day. I shall go with you and live with you, that will satisfy you and your wife. Go, bring a cart from your village.

Now Dwārkā was about 50 "yojanas" (nearly 200 "gātūts"*) from Dākore, and no one was willing for love or for money to give any cart to him for such a long journey. At last, moved by the old man's entreaties, a cowherd told him "I have a ricketty cart and a couple of attenuated bullocks, you are welcome to them." Boḍāṇā sold his utensils to obtain the wherewithal to maintain the bullocks on the way and reached Dwārkā safely. The Gugalīs seeing him return so soon suspected his design and put double locks on the Mandir of Rañchhodji at night, and kept watch and ward. But despite all these precautions, Rañchhodji quietly walked out, awakened Boḍāṇā, told him to drive, and outside the gates of Dwārkā, told his devotee to go to sleep, while he himself relieved him of the goad.

The bullocks ran very swiftly, and at Simloj village Rañchhodji awakened his Bhagat and inquired how far Dākore lay. Boḍāṇā replied that it was only a "kos" distant. Rañchhodji, therefore, rested under a nimb tree at Simloj in early morning. This halt has been commemorated with the placing of footprints of Śrī Kṛṣṇa, and the branch of the pungent Nimb tree which shaded the party for a while, miraculously turned sweet. This has been recorded in the popular Gujarāṭi Garbā† as well as in the Māhātmya‡ and then Boḍāṇā drove him to Dākore early in the morning. That day was Kārtik Sud 15 Samvat 1212. Gaṅgā did Ārti (display of lights with singing of hymns) and offered him what she had to eat.

The Gugalīs at Dwārkā, however, finding Rañchhodji no longer in the temple went to their Prince. With him and a large following, they pursued Boḍāṇā and succeeded in reaching the outskirts of Dākore on the 14th day of the month. Rañchhodji, of course, knew this and told Boḍāṇā to conceal him in Gomatī, a little stream (or reservoir) at Dākore, (which is alleged to have followed Rañchhodji from Dwārkā) and to go and meet the Gugalīs with presents of curds, etc. Boḍāṇā did go, but was killed by the throw of a lance as soon as he was descried by the Gugalīs. The popular Garbā, however, says he was not killed, as even according to the "Māhātmya," Rañchhodji protected Boḍāṇā and received the blow aimed at him. The wound inflicted on Rañchhodji bled and the blood coloured the water of Gomatī at the spot where Rañchhodji lay. Some of the Gugalīs went into the water and found the image; but they could not move it.

* According to "Mirāt-i-Ahmedi" 125 "kos", i.e. 250 miles from Ahmedabad.

† "आरखा लीमडामा एक डाळ मीटुं, हो रणछोड रंगोला।"

‡ "यच्च निम्बतरुस्तत्र स्थितं भगवता क्षणं ।
कुण्ठोपरि च तच्छाखा कत्राकारेण या भवत् ॥

संजाता मधुरा सैव भगवत्स्थितिस्तूचका ।

ईदृशः कुण्ठमहिमा वृक्षेभ्यो हरेः कृपा ॥ अः ४, श्लो ३२, ३३.

Thereupon there was a great deal of wailing and gnashing of teeth among them, and the whole party of Gugalīs fasted for several days to wipe off their guilt, and to get back the affection of the God.—Gaṅgā, however, could not endure the sight of so many brāhmins fasting, and when Rañchhodjī came to her one night, as usual, to take his meals, a “roṭalā” (loaf of Kodrā, a humble kind of grain) she besought him to be gracious towards the Gugalīs and promised to give him sweet “lāḍus” to eat, if he complied with her request and threatened if he did not, to give him no food at all. Gaṅgā had been as good a devotee of Rañchhodjī as Boḍānā, and Rañchhodjī treated her as a mother. So nothing worth, Rañachhodjī told her, “Dear Gaṅgā, these brāhmins, do not want me, but Gold. Just ask them if they would not take my weight in Gold, and you would see they would at once say ‘yes.’ Test them in this way. In the meantime, I am hungry, let me have those ‘lāḍus’.” He got his lāḍus, and Gaṅgā found that the Gugalīs were really mourning, not the loss of Rañachhodjī, but the loss of the emoluments His presence used to bring them.

They agreed to take Rañachhodjī’s weight in gold and to pass writing to the effect that they would not carry him to Dwārkā. The documents were passed; but where was the gold to come? Rañchhodjī, however, told Gaṅgā to have a huge pair of scales hung on the bank of the Gomati, near the place, where he lay concealed, and to bring her little “Wālī” (nose-ring) weighing only half a “wāla” of gold with her.* This was done and Gaṅgā went into the water and brought out Rañachhodjī; and at His instance, put Him in one scale and the “wālī” in the other. The wālī was found to weigh much more to the dismay of the Gugalīs, who becoming utterly hopeless, cast down their faces and were sorely grieved.

The incident narrating the weighing of the image of Dwārkānāth against gold, just to satisfy the greed of Gugalī Brāhmin worshippers ultimately turned down on them; as the idol, miraculously enough, proved to be lighter than a gold nose-ring of Gaṅgābāi, weighing only half a Māśā or a vāla (1/32th part of a toḷā) and a quarter, when a tulasi-leaf was placed along with it.

A similar hit on Satyabhāmā’s vanity of wealth and riches is recorded in Bengali literature.† Once Satyabhāmā having been found in a mood of vanity arising out of enormous riches, Kṛṣṇa desired to teach her a lesson, though in an indirect way. He asked Nārada to go to Satyabhāmā and request her for a gift. Satyabhāmā was just enjoying a swing, when Nārada appeared with a viṇā in hand. She rose up to receive him and asked what she could do for him. He simply said, I have come to you for a gift. Rolling in riches as she was, Satyabhāmā immediately requested him to let her know what he desired to have.

Nārada, to her embarrassment, simply said “I want Śrīkṛṣṇa.” At this, she began to feel the ground sliding away from her feet as she

* The “Māhātmya” gives the weight of the nose-ring to be half a “māśā”:—

‘अहो क्व नासिकाभूषा माषार्धस्वर्णनिर्मिता’ । अ. ८, श्लो. ३७.

† Vide, Dineśa Candra Sen’s “Baṅga Sāhitya Paricaya,” Vol. I, p. 809 (Calcutta University), a selection from “Gourāṅga Dāser Bhāgavata.”

realised the seriousness of the boon—to part with her lord. She requested him to repeat the demand to see if he had made a slip in asking. When Nārada was emphatic about his request, she tried to prevail upon him to accept anything else in lieu of Śrī Kṛṣṇa, even gold ; if he were pleased to accept as much as her Lord would weigh.—With apparent reluctance, Nārada agreed to accept gold as stipulated for.

Immediately scales were sent for ; and in one of the scales Śrīkṛṣṇa was placed and in the other she began to put her gold ornaments, one after the other. The scale of ornaments could not come down in spite of all the ornaments of Satyabhāmā having been placed therein, as it appeared, Kṛṣṇa was getting heavier and heavier. She brought many more from her cupboard and treasury, yet the other scale would not come up ! She, at first, felt astonished at this, but soon felt slighted and hurt as her vanity of riches proved to be hollow. She ran down to Rkmini if she could save the situation and help maintain her self-respect. Rkmini who was alive to the glory and greatness of Śrīkṛṣṇa, soon suggested to place a “Tulasi-leaf” in between the heap of gold ornaments.

The suggestion, establishing the greatness of Tulasi leaves so dear to Śrīkṛṣṇa—the Lord of Laxmi—which was much more than even gold, soon proved to be effective. The scale with Śrī Kṛṣṇa was raised up ; and lo ! the ornaments weighed more : Nārada went away with ornaments to the utter satisfaction of Satyabhāmā, now grown meek and humble.

Mirābāi refers in a song of hers to have purchased Govinda in return for her devotion with full knowledge of the consequences.†

Gaṅgā pitied them, but Raṇachhodjī wanted to smite their conscience and thus purify their hearts. They gave up their greed of money and began to pray to Raṇachhodjī with unselfish devotion. Raṇachhodjī told them, “In the Sāvitrī step-well near Dwārkā, there is an image of mine. Take it out on Kārtik Pūrṇimā (full-moonday) and instal it in my Mandir at Dwārkā.” The impatient Gugalīs who took 16 days to return to Dwārkā, however, drew out the image before that date ; and hence it is said it was much rough and unpolished than the original image.

So long as Gaṅgā was alive, she worshipped and fed and served the image herself, but after 3 years, she followed Boḍānā to Vaikuṇṭha, and then we are told, her “guru” (corrupted to “Gor”) used to officiate at the services. In course of time three sections of the sevakas—the Tapodhanas, the Śrīgaudaṣas or the Mewādās and the Khedāvālas who were “Pārṣadas” of Viṣṇu in previous birth became such officiators.

But for 400 years Śrī Raṇachhodjī appears to have worked no miracles and to have remained like an ordinary idol by the side of Daṅkanāth

† “माई ! मेंने गोविन्द लीनी वगमोक ।
कोई कहे हलकी, कोई कहे भारी ।
लीयो में तराजुमें तोक ॥ माई • ॥”

Mahādeva,* and all this time Kaliyuga troubled the people. His consort Laxmi, who had of course followed him to Dākore, wanted him to have a Mandir; but he said, "In Kaliyuga, the rich man's wealth is not good to have for my temple." Laxmi, however, said that "there was one rich man, a Baniā at Cambay of the name of Naṇḍana whose wealth was worthy of acceptance, as in a previous stage of his life this man had been poor and she had given him then a promise that he would be in another birth rich and would use his riches for the best purpose."

Thereupon Raṇachhodji said he too had given a similar promise to a Brāhmin in Draviḍa, a devotee of Veṅkaṭeśa, who would be born in the Tāmbvekar family, after a couple of centuries; and in the meanwhile, Raṇachhodji had no objection to his consort prompting Naṇḍana, to build a Mandir. So Naṇḍana built the temple called "Laxmiji's temple" at Dākore; but when the temple was ready, Raṇachhodji would not move, until a descendant of Boḍānā Dīpasing was found, and he alone was able to move him and take him to the new Mandir.

Here remained Laxmi Nārāyaṇa for about 200 years when the Muslim rule came to an end, until Gopāla Jagannāth Tāmbvekar on his way to Dwārkā, had a dream, that the Dwārkānāth (the Lord of Dwārkā) he was going to visit was at Dākore, and that as Laxmiji's temple was too narrow for all the people who wanted to worship, he should build another, and place the image on a high pedestal so as to be visible to all, even from the outer court-yard.

Gopāla Tāmbvekar, a Dakṣiṇī Brāhmin, who was a devotee of Veṅkaṭeśa, accordingly built the present temple; but Raṇachhodji as before, did not move to it, until another descendant of Boḍānā, Rāmasing by name, took him up in his arms.† Laxmiji remained in the first temple as Raṇachhodji told her "that the original temple should not be deserted and that she should remain there;" "On every Ekādaśī (the 11th of every Sud or Wad) and on every Friday, I shall come to you in the Svarūpa (form) of Bāla-Kṛṣṇa," and hence on these days, a moveable image of Gopāla Lālji is always taken on an elephant or a carriage in formal procession (Rathajātrā) to Laxmiji's mandir. Raṇachhodji's own image is immovable and remains in a standing posture in the Nija Mandir. By his side, however, are the moveable images of Laxmi and his other favourite queen Satyabhāmā and also the image of Gopāla

* "ढंकप्राप्ते यात्रिणां संघं चान्योन्यमर्दनम् ।
 कृद्धानां दुर्बलानां च नाऽभूत् कृष्णस्य दर्शनम् ॥
 संप्राप्ता बहवा भक्तिं गोविन्दे दृढभावतः ।
 पापिनामपि चेतस्तु कृष्णे भक्तिं र्वर्जयत ॥
 दृष्ट्वा जनानां संभर्दं दुर्बलक्षयहेतुकं ।
 आकृष्य निज माहात्म्यं स्थितवान् द्वारकेश्वरः ॥
 ततो जनानां भावो ऽपि क्षीणो ऽभूत्प्रतिवासरम् ।
 विप्रास्तं पूजयन्ति स्म मूर्ते साधारणामिव ॥
 कृष्णश्चतुःशताब्दानि तस्थौ सामान्यमूर्तिवत् ॥" अ. १२.

† "Kothli Sānth" is paid from the revenues of the village of Dākore to the descendants of the Rajput Boḍānā, in lieu of certain lands which they held, as the original custodians of the image.

Lālaji. At night time, these moveable images are taken to the Sajjā-Mandir and supposed to sleep there.

It appears from the "Garbā of Raṇachhoḍji," that, Raṇachhoḍji came to Dākore in Samvat 1212 ; that for, about 400 years he was accessible for "darśana" to all, on the bank of the Gomati, until it was installed in the Laxmīji temple built by the Cambay merchant ; that in Samvat 1791 Raṇachhoḍji was installed in a Mandir built by Ratansing (may be the temple of Trikamji just on the bank of Gomati) the Deputy (Vajir) of Abhesing, a rājā, who had come from Mārṇār (see *Infra*). However, at the time of a crowded fair on a Mānikhāri Pūnama in this temple, it was found to be too small and inconvenient, whereupon Raṇachhoḍji prompted Tāmbvekar an inhabitant of Poona to build the present temple in order that all might have "darśana." The building started early in 1826 Samvat, took no less than 3 years ; and in 1828 Samvat Raṇachhoḍji was removed to it by a descendant of Boḍāṇā, excepting whom none could remove him.

Turning the Baroda Gazetteer, we find (Bom. Gaz., Vol. VII, Baroda, page 171) that in 1725, A. D. (1781 Samvat) Pilāji Gāekwād joined two other chiefs on the Mahi and conducted measures to oppose the Mahomedan Viceroy who had gained over the assistance of the Bābis and of Abhesing, Rājā of Jodhpur. § Pilāji was defeated and it was probably after this victory that Abhesing built the temple. His Vajir Ratansing is mentioned at p. 175 of the Gazetteer. The merit of building the temple however, has been denied to Abhesing in the "Daṅkapur Māhātmya," probably because Abhesing was a most unscrupulous man having had Pilāji assassinated at Dākore in 1732 A. D.

It is in evidence, that Tāmbvekar not only got the grant of Dākore renewed from the Peśvā Mādhava Rāo (*Appendix A*), but also he secured the grant of the village of Kaṇajari in Mahudha tālukā Dist. Kairā, from Sayāji Rāo I Gāekwār immediately after the building of the temple had started (*Appendix B*). The building was commenced, it appears, in 1769 A. D. and completed in 1772 A. D. The grant of Kaṇajari was renewed by Govinda Rāo Gāekwād (*Appendix C*).

The image of Raṇachhoḍji has been about 800 years in Dākore. In 1212 samvat Kumārpal reigned at Aṇhilpur. In 1781 samvat, when the first temple was built by Abhesing, Governor of Gujarāt, Mahammad Shāh was Emperor of Delhi; but his viceroy in Gujarāt Nizāmulmuluk had thrown off his yoke, and Hamidkhān, the uncle and deputy of Nizāmulmuluk, invoked the aid of Pilāji (the founder of the Gāekwār family) and rewarded him with half the Chauth of Gujarāt. The period between these two dates was a most eventful one. The last Hindu King of Gujarāt Karaṇa Vāghelo had been defeated by Allāuddin's officers in 1297 A. D. (1353 Samvat). The Sultāns of Ahmedabad had their day upto 1572 A. D. (Samvat 1628),

§ "Mahārājā Abhayasingh after defeating Sarbuland Khān, the previous Subedar of Gujarāt, took charge of the province in 1730 A. D. In 1733 A. D. he returned to Jodhpur, appointing Ratansing Bhaṇḍāri as his deputy. His man, a Rajput of the Indā clan named Lakhdar, killed Pilāji at Dākore in 1732. Ratansing Bhaṇḍāri remained at Gujarat upto 1737 A. D."—From a letter of Mahāmahopādhyāya Paṇḍit Bīśveśvara Nāth Reu, Superintendent, Jodhpur Museum D/6-7-'42.

when Akbar conquered Gujarāt; and in 1725 A. D. (1781 Samvat) a new power had arisen which eventually demolished the Moghul Empire itself. The custodians of the idol could hardly have had a good time of it during the period of Mahommedan ascendancy.

But who were the custodians of the image and the temple? The "Dākore Māhātmys" simply says that after Gaṅgā's death, her "Gor" (Guru) took charge of the idol, but it does not tell us who the 'gor' was. It, however, states that before Bodāṇā took to his pilgrimages to Dwārkā, he was a worshipper at Daṅkanāth's temple. That was a temple of Mahādeva and it is said that Kṛṣṇa, while passing with Bhīma (the second of the Pāṇḍavas) through Dākore on his way to Dwārkā, had promised to Mahādeva that he would one day make Dākore his permanent abode.

Daṅkanāth's temple still exists and stands at a distance of only 200 paces from Raṇachhodjī's Mandir on the eastern bank of the Gomati. It is in charge of Tapodhana Brāhmins, as all temples of Śiva are. It is probable therefore that Gaṅgābāi's Gor was a Tapodhana. It is pretty certain, at any rate, that Raṇachhodjī's image was for a long time in charge of Tapodhana Brāhmins. The image used to be at Daṅkanāth's until it was removed to Laxmiji's Mandir, which is only a quarter of a mile from the present temple.

This image of Dwārkeśa was worshipped by the Tapodhanas until about 450 years ago, when Harirāyaji Māhārāj of Śrināthji of Mewār in Udepur (Samvat 1682) objected to such worship on the ground that the Tapodhanas were inferior Brāhmins and accordingly joined the Śrīgors or Mewādas and the Khedāwāls with them. The "sevā-prakāra"—the mode of worshipping was fixed by Harirāyaji whose "Beṭhaka" is situated on the other bank of Gomati, by the side of Trikamji's temple. The Tapodhanas upto date enjoy one-half of the offerings to the temple, while the Śrīgors and the Khedāwāls divide the other half equally between them. The Tapodhanas also keep the keys of the temple, and every morning and evening one of them has to be present to open and close the temple. Their number is also the largest. When the vaiṣṇavas felt scandalised at their God being touched and fed by Tapodhanas,* the Khedāwāls were induced to undertake the office of cooks and Sevakas, but as Brāhmins who became cooks are considered on a lower level in society, the Khedāwāls could not get married. Therefore, they induced the Śrīgors, on promising them one-half of their income to undertake the cooking business. Some believe that the Śrīgors came first and then the Khedāwāls followed. It is pretty certain, however, that the Khedāwāls perform the regular services in the temple while the Śrīgors cook the "bhogas" (food for the idol) and do "Ārati".

This is all that we know about the establishment of the idol, the origin of the temple, and the origin of the "Sevakas". The image was established in the present temple for facilitating "darśana" and the deity, represented by the image, according to the Māhātmys does not favour

* The word "Tapodhana" implies the inferiority of this class of Brāhmins as distinguished from "Tapodhanas" which as applied to eminent Rīśis and Brāhmins, was a generic courteous epithet.

exclusiveness or greed of gold.* He was represented to Boḍāṇā as a God, who did not despise a true devotee, though the devotee might be a Bhil, and he punished the Gugalis signally for their cupidity.

The sevakas who were in charge of the idol, the temple and the various services pleaded prescription and usage, and there was a litigation to this effect in court in 1883. The oldest document (dated 1740 A. D.) produced by the sevakas bore the seal of Mominkhān, the Viceroy of Gujarāt under Emperor Mahammad Shāh 1720-1748 A. D. who died in 1743 A. D. and who was succeeded by Fidāuddin Khān, who was forced to flee from the country by Dāmāji in 1744 A. D.

In a document addressed to the Mutasaddidār or Thāṇdār of Thās-rā these officers are "directed not to molest the sevakas of Raṇachhoḍji, not to covet whatever any people coming to Raṇachhoḍji may give to the "sevakas," and to leave such moneys with the sevakas." The other two documents are merely assurances to the sevakas of the Viceroy's protection. It appears that the sevakas after the first Mandir was built in 1725 A. D. had a certain income from the temple; that income was not secure from the cupidity of Government officers; that the sevakas were probably also persecuted for worshipping the idol; and that in payment probably of a handsome "nazar" to the Viceroy or an agent to his family, the sevaka succeeded in obtaining protection before the country passed into the hands of the Marāṭhās.

The Mahomedan rule practically came to an end in 1753 A. D.; and the next series of documents available bear the seal of the Gāekwār. In one document Govindrāo Gāekwār directs 2½ rupees to be given to Dambat Wanchidās every month in his name, and also certain provisions every day, apparently for the use of the idol.

Fatesing Gāekwār, directed one Rājeśri Nāgorām Gosāvin that the income of the village of Kanjri should be given to 'Vedamūrti Dambat Wanchidās' as Varśāsana (the formal grant had already been made to the Tāmbvekar for the Sawasthān by Sayājirāo who reigned from 1771 to 1778), while the latter directs that out of the income of this village 'which is in Dharmādā for Śri Raṇachhoḍji' Rs. 71-4-0 should be given to Tirtha Upādhiā Sevaka Dambat Wanchidās for 'tulsi' offerings. Govindrāo reigned from 1768 to 1771, and Fatesing, the successor of Sayājirāo I, from 1778 to 1789 A.D. Wanchidās or Banchidās is mentioned in many documents by name; and must, therefore, have been the head of the sevakas. 'Tirtha Upādhiā' is a term used by Dakṣiṇis for Tirtha Gors, and Wanchidās' son appears to have become Tirtha Gor of Fatesing Gāekwār. These documents, therefore, prove that after the building of the present temple, the income of the temple increased, that one of the sevakas became the Tirtha-Gor of the ruling authority and that Tirtha-Gors used to make Tulsi offerings for their Yajamānas. There was no dread and the Gors were free to do what they could to attract the pilgrims to the temple.

The idol and its Mandir appear to have received considerable attention from the Gāekwār. For, besides the above grants, we find Sayā-

* The rules made by the Sevakas lay down certain fees for certain pūjās and ceremonies, and a fee of 5 pice had to be paid for a ticket for 'darśana,' as tickets were actually issued since October 1883.

jirāo beautifying the dias (or 'Sinhāsana') on which the image stands with four gold-filled silver pillars on its four sides, and erecting a lattice breast-high in front of the main doors to the west, at a cost of Rupees one lac and ten thousand. A document of Samvat 1916 is traced recording the establishment of a guard of five sepoys and a clerk to be posted in Gāekwār's residence at Dākore to look after the sheets of gold and silver fitted on the dias and the 'kalaśa' of the temple. The Gāekwārs sent presents of red powder for use on the Holi. The Mahārāṇi had personally gone to Dākore when these gold and silver sheets were presented to the temple in Vaiśākha of Samvat 1916 (1860 A.D.) (See *Appendix D*), in 1881 Samvat (1835 A.D.) of a 'māfo' (an ornamental carriage or howdāh) with bullocks, in 1892 Samvat of a 'chhatra' (umbrella) and 'Sigrām' in 1898 Samvat, and of tiger-nails coated with precious metals in 1900 Samvat.

The temple continued to prosper after the fall of Mārāthā power and the introduction of English rule. The two villages of Dākore and Kañjri, which belonged to the idol and were managed by the Tāmbvekaras continued to be the property of the temple, and one of the varśāsans enjoyed by the idol under the Gāekwār appears to have been confirmed. The Māmlatdār of Thāsrā sends to 'Sevaka Samasta.' (i.e., to the whole body of Sevakas), and to the Bhaṇḍāri (or the treasurer of the idol) Rs. 13½ and 65 rish (100 rishies = 1 rupee), being a 'nemnuk of the devasthān' to be applied to Śrī Raṇachhodjī's 'annakūta' (literally a heap of grain, but meaning as assortment of rich viands offered to the idol on certain holidays).

The term 'Bhaṇḍāri' does not occur in any of the previous documents, and perhaps its occurrence in these, attracted liberal donations from the Vaiṣṇavas. It has been abundantly proved that the bhaṇḍāri (treasurer) is a nominee of the sevakas taking care of the jewels which suggests that the sevakas were the custodians of all donations and offerings made to the idol by their agent, the bhaṇḍāri, who was usually a celebrated bairāgi and had no need of a salary. It may also be inferred by the use of the words 'sevaka samasta' that the first families of Tapodhanas, Śrīgoras and Khedāvāls had multiplied in course of time and found it necessary to use an abstract phrase and to appoint an officer, the bhaṇḍāri, to represent them all.

About 80 years ago, a Vaiṣṇava Mahārāja of Lucknow (Bhaṭṭjī) appears to have paid a visit to Dākore, and instituted a charity at a place not far from Raṇachhodjī's temple. This institution has been supported by the Vaiṣṇavās to such an extent that it now gives out about 17,000 rupees every year as alms. The Mahārāj adorned the Sabhā Maṇḍap, the front court-yard of Raṇachhodjī's temple with marble stones, and directed a Sāmagrī to be given every day by the charity. This sāmagrī consists of no less than one and half maund of cooked food, and the manager of the charity takes it every day to the temple, gives it to the sevakas for the purposes of its being offered to the idol, and after this ceremony is concluded, and after food enough for three sevakas (of the three castes) is taken out, brings back the rest to be doled out to the poor.

In 1926 Samvat (1870 A. D.) another Vaiṣṇava Mahārāj, Śrī Maṭu-ji came to Dākore and wanted to give what is called 'Chhapan Bhoga' to the idol. The term literally means '56 dishes of food' but as a matter of fact, the dishes exceed 100 and sometimes 200. It is the grandest dinner that can be given to the idol, and a document, dated Māgha Vadya 2,

1926, Samvat purports to be a letter from the Mahārāj, asking the Bhaṇḍārī Rāmaratandās Harabhajandās to give permission for offering this Bhogas on behalf of 'Sevaka samasta.' The substance of the letter is: "The God had inspired Chhapan Bhog to me. I meant to give it on Chaitra Shudh 12, according to Muhūrta (*i.e.*, prediction of auspicious days). Your permission is necessary. Other Gosāi Mahārājas are also to come. Arrange for their residence. All Vaiṣṇavas will come for darśana. Arrange for their Darśana." This was perhaps as a matter of courtesy, to seek the permission of sevakas.

In Samvat 1920 a rich Vaiṣṇava, Mathur of Ānand gave Rs. 2,000 to the Mandir in trust for a new Bhoga to be called the 'Sakribhoga.' The interest was to be spent on this Bhoga and the fund was to remain untouched. Another Vaisnava Jamnādās gave 2,100 rupees for the same Bhoga and now this Bhoga is the 6th Bhoga the idol gets. The money was deposited with the banking firm of 'Gopāla Lālji' called after the idol's name. The firm though called after the idol is managed by the sevakas on true business principles and its 'hundies' are honoured and cashed on favourable terms by merchants. This is certainly a significant fact, for it shows that the sevakas have a real substantial interest in the income of the temple.

There is abundant evidence to prove that the sevakas have for a long time, been in the habit of dividing the proceeds of the temple collected in the Ghāgar, the 'bhogas' placed before the idol from the temple property, the worn out ornaments and clothes of the idol and the offerings of perishable articles in kind. The idol has cows which are in their charge and this banking firm, which is also in their charge. The accounts of the Mandir income (apart from those of the firm) are kept in triplicate, one set for 'sevakasamasta,' another for the Tapodhanas, and a third for one of the other two equal partners. The bhaṇḍārī who controls these accountants, the berāgi in charge of the Sajjā Mandir, the berāgi in charge of Laxmiji's mandir, the mace-bearer, the peons and the large establishment of the idol, comprising a store-keeper of grain, another of vegetables, another of flowers, the cow-keepers, and the kārkun in charge of the accounts relating to the produce of the dairy, the milk-boiler, the ghee-lamp-lighter, the water-bearer, the two cooks, the cleanser of utensils, the bringer of provisions, the two men who sweep the temple, are all under their control.

They are directly concerned in the prosperity of the temple and in the regulation of its services according to the true orthodox notions on the subject. It was one of them, who 50 years ago opposed a Police Inspector, Mr. Hykoop, and assaulted him rather than allow him to defile the Mandir with his presence. He had to go to jail for it, but the result was an order issued by the Commissioner, enjoining all European officers not to trespass upon the temple or intrude on the services. The sevakas have certainly identified themselves with the temple, and two of them have the images of Boḍāṇā in two temples, while a third has another temple of Satyabhāmā. Through the munificence of a Lēvā Kuṇbi Śēth, son of Jēthābhāi, who died in 1927 Samvat, were covered the walls of the Sajjāmandir with mirror glasses and a lattice was constructed in front of it, at a total cost of about 7,000 rupees. His brother built a rest-house at Dākore, and his descendants give 6 maunds of dāl (pulse) every year to the Mandir. The Tagia Mahājan, whose fund

used to be managed by Jethābhāi, offer clothes on the Diwālī and give 5 maunds of wheat and 25 rupees every month. Such fixed donations to the temple are too many to be enumerated. For example, the Umreth people for the last 2 or 3 centuries have enjoyed the right of having their presents of clothes and Rājabhoga first offered to the idol on the Prabodhini Bārāśa (Kārtik Sud 12) the day on which Viṣṇu is supposed to have come out of the Earth. On the same day the Mahājan of Oḍ Bhāgol at Ānand (who some years ago) put up a silver flagstaff worth 2,000 rupees, offer clothes worth 75 rupees, while another Mahājan offers a "Rājabhoga."

The sevakas, besides possessing the power of instituting new Bhoga in addition to the old ones and consenting to the ornamentation of the temple, have the powers of allowing the idol of Gopāla Lalājī to be taken out of Dākore as Raṇachhodjī's representative. About 50 years ago, one Mathur a wealthy Vaiṣṇava who wanted to establish a sanctuary in Raṇachhodjī's garden at Umreth (there is a garden there and Raṇachhodjī has three other villages besides Dākore and Kanjari) asked the sevakas to allow him to take Gopāla Lalājī to Umreth in order to consecrate the temple he wanted to build. He fasted for one month, and at length the sevakas took the image to Umreth, and had His foot-marks, carved out in masonry at the request of Mathur. These foot-marks are worshipped by the Umreth people, who gave 1,000 rupees besides the 1,000 rupees that Mathur paid for the idol's visit, *inter alia*.

It appears from what has been stated before that (a) long before Tāmbvekar got the management of Dākore village, it was granted by the Moghul Government for the support of the temple of Raṇachhodjī; (b) that after the country passed into the hands of the Peśvā and the Gāekwād, the village was managed by their officials on account of the temple; (c) that Gopāla Nāik Tāmbvekar, who built the temple in Śaka 1693 (A.D. 1772) applied to the Peśvā to transfer to his management the village of Dākore, which was done by Sanad, with a condition that the revenue of the village be all laid out for the expenses of the temple, (d) that after Gopāla Nāik commenced building the temple, he petitioned the Gāekwād Sāyājirāo I, for some new grant to meet the enlarged expenses of the new temple, and the Gāekwād made an offering (*Kṛṣṇārpaṇa*) of the village of Kanjari to the "Śrī"—to the idol of Raṇachhodjī entrusting it to the said Gopāla Nāik, who was to enjoy (*upabhoga*) it hereditarily. (Literally "upabhoga" means enjoyment; however it does not mean a private gift, because the Sanad recites that the new "inām" of gift is necessary for the additional expenses of the temple on its being enlarged, and then comes the declaration that the village has been offered up to the "Śrī"; (e) that subsequent Gāekwāds considering it necessary, made arrangements for the preservation of the revenues of the village against waste by appointing their officers as agents, and (f) that after the accession of the British Government, the Collector of Kaira was obliged to control the financial affairs of the temple which appeared to be very much mismanaged by the descendants and agents of Gopāla Tāmbvekar; and the village of Kanjari (originally in Mahudhā Tāluka, now in the Mātar Tālukā) was placed under the direct management of one of the District Government official. These facts were held to regard the Tāmbvekar as the trustees for the proper application of the income of the two villages towards the expenses of the temple.

Gopāla Nāik Tāmbekar,* the benevolent builder of the existing temple at Dākore was a Rgvedī Deśastha Brāhmin of Kāśyapa gotra, Āśvalāyana sūtra. His father's name was Viśvanāth (alias Jagannāth according to various *sanads*). Village Tāmbe is situated in the Satārā Zilla, in Tālukā Vālvē and on the banks of river of Kṛṣṇā, near Kāsgām. He purchased the Jāgir of Mālkhed, on the banks of Kṛṣṇā from Pārvatibāi Bhonsle of Sirālī, and gave over in charity the income of the village to 54 Brāhmins, whom he presented furnished houses with provisions lasting for one year, which testifies to his charitable disposition.

Gopālā Nāik had earned lacs in banking business during the reign of Savāi Mādhavarāo Peśvā 1774-1795 A. D. As Paraśurām Nāik was the great banker advancing big loans to Bājirao, so Gopālā Nāik was the adventurous banker for Mahādji Śindē. He built one Ghāṭa (steps) on Kṛṣṇā river and also a temple of Viṣṇu, to which he gifted over property worth lacs of rupees.

In 1772 he completed the temple of Raṇachhodjī at Dākore in Thāsrā Tālukā in Kairā District. In furtherance of this purpose he had secured the renewal of the grant of Dākore village from Mādhavarāo Peśvā (1745-1772) just to meet the expenses of the worship and maintenance of the Viṣṇu temple in the latter part of Mādhavarāo's career, i.e., in 1770 A.D. when the temple was under construction.

Tāmbekar was one of the Sardārs of Peśvā. The "*Harivaṃśā cī Bakhar*" records the following story about Gopālā Rāo. Gopālā Nāik having been pretentious enough to append the honorific suffix "Rāo" at the end of his name, the "three and a half Rāo" famous during the Peśvā's regime they being Murāra Rāo Ghorpaḍe, Bhavān Rāo Pratinidhi and half Rāo Mādhava Rāo Peśvā—the second of these, namely Bhavān Rāo feeling spited at this claim of Gopālā Nāik, sent about 50 to 100 men, who torn the palanquin of Tāmbekar to pieces and killed him.

A descendant of this Gopālā Nāik Tāmbekar, had taken part in Baroda affairs of administration. Bhāu Tāmbe (Tāmbekar) was a De-wān of Baroda from 1849 to 1854 A. D., whose residence (wāḍā) in the city possesses typical mural paintings and painted wooden doors of both secular and religious topics. They mark a complex style of wall-painting which grew and developed under the Rājput—Marāṭhā patronage during the 18th and the 19th centuries.†

An inscription on stone fixed in the wall of the Kothī or the office of the Tāmbekar—the managers, adjacent to the right side of the temple, records in Sanskrit, verses in Śardūla meter the date of the installation of the image of Viṣṇu in the temple, and offers a glowing description of the high turrets thereof. The building of the temple had been started about two years earlier i.e., in 1770 A. D. but was completed in 1772. It is noteworthy that along with the Vikrama era, the Śāka era prevalent in India, South of Narmadā, has been given, as the donor hailed from Satārā. The renewal of the sanad for Dākore from Mādhava Rāo Peśvā, and a new gift of Kaṇjari by Sayājī Rāo Gāekwād are both

* See "*Madhyayugina Caritra Kośa*" by Siddheśvara Śāstri Citrāv, Poona (1937), pp. 326-27.

† For reproductions of some of these paintings, see "*Archeological Reports of the Baroda State*."

dated in Saka year 1691, which is equivalent to 1826 Samvat, 1770 A.D. The inscription reads :—

“Bliss to all ! In the year marked by Vasu (8), eyes (2), elephants of quarters (8) and earth (1) *i.e.*, in 1828 of the Vikrama Rājasekhara era named Sūbhakṛta, in the auspicious Ayana (*i.e.*, the period of six months) in the vernal season, on Monday, the auspicious 5th day of the bright half of the month of Māgha in the resplendant town of Daṅkāpur (1).

“May the lord of Śrī-Lakṣmī, established in the temple, to the east of Gomati (tank) decorated with high ramparts of variegated design and elegant domes made accessible with a stair-case studded with series of new gems, the pointed turrets of which are so high as to obstruct the path of solar rays on this earth,—may Lord Viṣṇu confer bliss on the learned Mayor or Lord of the town named Gopāla, of devoted mind (2).

“Bliss to all ! In the śāka year marked by moon (1), six (6), numerals (9) and fire (3), (*i.e.*, in 1693) of the Śālivāhana era named Khara, in the spring season, on Monday and the auspicious 5th day of the bright half of the month of Māgha—May the Lord of the Devas—Lord Viṣṇu of lotus eyes ever decorate this temple ! (3).”

“श्री रेस्तु ।

८२, ८, १.

श्रीमद्विक्रमराजशेखर शके वस्वाक्षिमातंगभू ।

संख्याब्दे ह्यभिधानतः शुभकृति श्री सौम्यके चायने ॥

वासंते च ऋतौ तपस्य बहुले पक्षे दिने शोभने ।

पंचम्यां विधुवःसरेप्र विलसतु ढंकापुरे शोभने ॥ १ ॥

गोमलाश्व पुरोदिशि प्रविततप्राकारसंराजिते ।

सम्प्रग्नूतनचित्ररत्नपटलासेपानसंशोभिते ॥

शृंगाग्रै पिहितार्कमार्गविभवे देवालये संस्थितः ।

श्रीशिः शं कृपया तनोतु सुमतेः गोपाल नाम्नः प्रभोः ॥ २ ॥

स्वस्ति श्रीमति शालिवाहन शके षडन्यङ्क पट् चंद्रमा-

स्संख्याब्दे खरनामके मधु ऋतौ सौम्यायने शोभने ।

तापस्ये शुचिपक्षके शुभ दिने पंचम्यभिह्ये विधो-

र्बारे वारिजलोचनस्सुरपति देवालये शोभतु ॥ ३ ॥”

The image of Viṣṇu* is big enough (about 3.5 ft. high and 1.5 ft. broad) and is not of the small size as in the Vaiṣṇava temples of the Vallabha sect which worship the child Kṛṣṇa, excepting their Govardhanadhāri image at Nāthadwārā. Lord Kṛṣṇa, who settled later in life at Dwārakā, was worshipped in his mature form as a full-grown man; hence his image is not of a negligible size.

* For further details re: the twenty-four varieties of four-armed Viṣṇu, reader is referred to my paper on “Varieties of Viṣṇu images in western India,” in Dr. Bhagvānlāl Indrajī commemoration volume, “Gujarat Research Society Journal” (1937).

The 14th Adhyāya of the "Daṅkapur Māhātmya," describes in 8 poetic verses (3 to 10) in Puṣpitaḡrā metre, the image of Raṇachhoḡji and its splendour. The position of the symbols of the four-armed Viṣṇu as described in this "stotra" is as under :—

“किसलयमृदुलैर्भुजैश्चतुर्भिः । नेलिनीरथांगगदादरान् दधाने ।

धृतकमलकराग्रवणुरभ्ये । मम रतिरस्तु सदैव ङकपाले ॥ ३ ॥”

a lotus, a cakra, a gadā and a śaṅkha—starting from lower right hand—which gives us the formula of Śrīdhara.

(श्रं.धरो वारिजं चक्रं गदा शंखं दधाति च । रूपमण्डने । अ. ३, श्लो. १५)

However, the actual image that is in the temple and the colour-prints of which, are available in all sizes has variation in the order of symbols, viz., Padma, Gadā, Cakra and Śaṅkha giving us the identification to be that of Trivikrama.

(त्रिविक्रमः पद्मचक्रः । देवता मूर्तिप्रकरण । अ. ५, श्लो. ११.)

The special feature of this image of fine polished black granite is that its lower right hand is not held down, but is held upwards along with the upper right hand, and is so fashioned as to hold the flute with the tips of the fingers.*

It is so stated in works on Hindu Iconography that out of the many gods and their multiple manifestations, only some are held to be auspicious for certain class of people in society; for example the Śrīdhārī mūrti is auspicious for Sūdras†; whereas that of Trivikrama and of Vāmana are good for Vaiśyas. The temple of Laxmiji was built by Naṇḡdana of Cambay, a merchant and that of Raṇachhoḡji by Tāmbvekar, a banker by profession. The Sūdras are allowed free access to the temple, who feel equally happy at the sight of the God's idol.

The "Māhātmya" later on (Adh. 15, verses 29-31) refers to the Trivikrama form of Viṣṇu, which was brought to Daṅkapur by Vijayasimha, for which, a separate temple of Trikaṇaji has been instituted. It cannot be ascertained, therefore, how the Śrīdhara mūrti came in.§

* The original image is not allowed to be photographed on grounds of sanctity by the Temple Committee; hence an identical image from the ruins of Ghūmli has been reproduced through the kind offices of Sjt. Harilāl Māṇḡḡ, the Curator, Jāṇnagar Museum.

† (i) पूजिता श्रीधरी मूर्तिः शूद्राणां सौख्यदायिनी ।”

रूपमण्डने, अ. ३ श्लो. ५

(ii) “त्रिविक्रमो वामनश्च वैद्यानामर्चने शुभौ ।

रूपमण्डने, अ. ३ श्लो. ४

§ “वामनं रूपमास्थाय बलेर्हत्वा वसुंधरा ।

अत्रैव संस्थितं विष्णुं देवर्षयः समर्चयन् ॥

त्रिविक्रमो देववरः कृपालुः । श्री वामनत्वेन सुरेशवर्यः ।

बलिं छलिता गु चकार यक्ष । सुरेशकार्यं प्रणमामि तं वै ।

भक्तो विजयसिंहो मां द्वारकातो नयिष्यति ।

तदा ह्यनेन (त्रिविक्रम) रूपेण वसिष्ठाभि ह्यहमपि ॥”

क. मा. अ. १५, श्लो. २९-३१

The name "Ranachhoda" of Dwārkādhīśa has been explained etymologically, in two ways during the course of the "Daṅkapura Māhātmya," although the Sanskrita word "रणशौड" (clever in war) probably explains the correct meaning, as Kṛṣṇa had hardly lost a battle. However, firstly when Dwārakeśa asked Boḍāṇā to conceal him in the waters of Gomati tank, just to avoid a hand-to-hand skirmish on his account, i.e. one who avoided fight in a pitched battle, ① is called "Ranachhoda."

Secondly, the word has been explained in the "Māhātmya" as one who cut off or liquidated the debt of Vijayasingh in the form of utmost devotion by having agreed to come and stay at the devotee's house. ②

The various names of Viṣṇu image in Dākore are enumerated as under :—

"ऋण छोडो रणछोड स्तथा डंकपुरेश्वरः ।

डाकुरेशो द्वारकेश इ त्याग्याभिर्जेना जगुः ॥" अ. १२-५

Dākureśā is worshipped with "tulsi" leaves and butter mixed with sugar is offered to him with a copper coin only,—a present that would permit the pocket of even the poorest; because He is pleased merely with the pure and genuine devotion of man, and not with the presents he brings for Him.*

The temple is typical of the Hindu temples built in the 18th century. It has two big gates, one on the west and the other on the north. The temple with brickwalls and stone-pillars raised on a high plinth approached by a flight of 12 stone-steps, measures 168 feet from East to West and 151 from North to South, and has eight domes and twenty-four turrets, the highest of 90 feet. One finds on entering from these big gates, himself on a wide courtyard which leads to the temple after going up the steps, in the Sabhāmaṇḍapa. Beyond the Sabhāmandir comes the Nijamandir, the main room where Ranachhoda-jī's image stands. The platform on which it stands is called the Siṅhāsana. It is of marble, but surrounded by planks on which the worshippers sit or stand when doing pūjā. On the marble pedestal is another smaller pedestal, supporting the image which is of polished black stone and is about three and a half feet high. On this small pedestal stand, also small images of Lakṣmījī and Satyabhāmā and of Gopāla Lālji.

These are all moveable (*chala*) and are taken at night to the next room, which is divided from the Nijamandir by a Chauk and a lattice,

- ① "रणं युद्धमिति प्र ह्रुः छोडस्तु त्यागवाचकः ।
रणं त्यक्त्वा जले यातो रणछोड स्ततोऽभवत् ॥" अ. ४-२७.
- ② "उत्तमर्णाद् गृहीतं यद् तद् वस्तु ऋणमुच्यते ।
तथैव छोड शब्दस्तु मोचनार्थः प्रकीर्तितः ॥
ऋणं विजयसिंहस्य भक्तिरूपं विमोचितुम् ।
स्थितस्तद् गेहमागत्य ऋणछोरस्ततः स्मृतः ॥" अ. ४ श्लो. २२-२३
- * "शर्करां नवनीतं च गृहीत्वा ताम्रमुद्रया ।
दरिद्रोऽप्यर्पयद्भक्त्या तेन तुष्यति केशवः ।
द्वरेः संप्राणनं कर्तुं न धनानि प्रयोजनम् ।
छुद्र भावेन भगवान् तुष्यत्येव न पूजया ॥" अ. १४, श्लो. ३४-६-

and is called the Sajjāmandir (or dormitory). In the Sajjāmandir there is a small ante-chamber. Divided from the next ante-chamber is the Sabhāmaṇḍap which is reached directly from the western gate of the fortified walls which encircle the Mandir. The lattice is only breast high and has a door in it opposite the main western door of the Nijāmandir, through which the face of the idol can be seen. There is the figure of a tortoise (one of the Avatāras of Viṣṇu) in the Sabhā Maṇḍapa and from this place people, not caring to go into the Nijāmandir may have "darśana."

The Nijāmandir has four doors, one on the west opening on the small ante-chamber leading to the Sabhāmaṇḍapa, the other on the south leading to the Chauk of the Sajjāmandir, the third on the east opening into the Bhaṇḍāra or treasury of the idol, the fourth on the north opening on another Chauk which communicates on the east with the *phareṭāl*, (partition) from which worshippers come into the Nijāmandir, and on the North with the Prasāda-ghara whence bhogas are brought for the idol. In the same way the chauk between the Nijāmandir and the Sajjāmandir communicates on the east with an oṭlā to which worshippers pass on after passing through the Nijāmandir and having darśan of the Sajjāmandir through the lattice. To the east of the prasādaghar is the cookroom, where the bhogas are cooked (*Vide* Forbe's "Rāsamālā," page 594).

Below the Sabhāmaṇḍapa, there is a dīpamāla (a pillar of lights) where "tulās" usually take place. The first "tulā" or weighment was, as we have seen, of Raṇachhodjī on the banks of the Gomati; on that bank also, persons making vows have their children weighed with any articles they like and then give away the articles. For instance, *A* vows that if his son *B* recovers from a serious illness, he would have *B* weighed with rupees. Limbājī Diwān and one Motilāl had their sons so weighed and gave the money to the Mandir. Such vows are called "bādhā," and "tulās" are usually made in fulfilment of vows.

Below the Sabhā Maṇḍapa and all around the buildings above described, one sees a circular path used by pilgrims for "pradakṣiṇā" (circumambulation). The practice is to start from the oṭlā on which the Bhaṇḍāri sits near the Bhaṇḍār and to go the rounds 108 times with something in hand, say a coconut, a betelnut, a pice, a rupee, a fig, or any other article. 108 such articles with which a turner goes the rounds must be paid away. Near the circular path sit several mālīs, who sell "tula-i" leaves for "tulasi"—offerings, and flowers for flower-offerings. These mālīs remove to the sabhā-maṇḍapa during the monsoons.

Besides "darśana" a pilgrim may desire to touch the feet of the idol. This touching of the feet is called "*charaṇa sparśa*," and it cannot be well done without going upon the planks. So also he may desire to do "pañcāmṛta Pūjā" and "Kesara snāna" which also cannot be done without going upon the planks. The pilgrim may also desire to do what is called "Nochāvar," i.e., to see the idol after it is fully decked, and waving some money near its face, pay it away to ensure the idol against the evil eye. He may also wish to offer rājabhoga in which case the practice is to inform the Tāmbvekar (who has to supply provisions for the Rājabhoga every day), and then send provisions to the Mandir to be cooked there for the idol. A Rājabhoga costs from Rs. 14 to 20 rupees, and therefore, is not usually given by the poor, who generally offer "sāmagris," i.e., food less than a rājabhoga.

In order to follow the significance of "services" to the idol, it is necessary to know that the idol is supposed to be human being, requiring all the services a living Mahārājā would require. One of the meanings of the saying "*Yathā dehé tathā Dēvé*" is that a "deva" (an image of a deity) should be treated as if he had a deha (or a body); the anthropomorphic idea is fully carried out in practice; and Raṇachhodjī, therefore, is awakened in the morning and is supposed to brush his teeth and take a little breakfast before he is accessible for "darśan;" after the breakfast, the doors are opened, and what is called the "Maṅgalā Ārti" commences.

When the Ārti is done, any person, wishing to do, "pañchāmṛta pūjā" is allowed to do it. The "Pañchāmṛta" are milk, curds, ghee, sugar and honey and the pūjā is done anointing with these five things the feet of the idol (generally the toes) the worshipper generally applies these things himself, or their "Gor" applies the pañchāmṛta, while they themselves place their hand over the Gor's hands. After this pūjā is performed Śrī Raṇachhodjī has his bath, and the bath commences with what is called the "Kesarasnāna." This Snāna, when the pañchāmṛta pūjā is performed, is the last part of that pūjā, and consists in the worshipper taking saffron-water and pouring it over the head of the idol. After the Kesarasnāna, Raṇachhodjī is anointed with oil and scents and then bathed with water brought in silver utensils. The water is, of course, hot in winter and tepid in summer, and the scents vary according to the seasons. All this is what is called the Maṅgalā service.

After the maṅgalā comes the "Singāra" i.e., Raṇachhodjī is clothed and adorned with ornaments. After he is in full dress, he gets the "singā-rabhoga" which consists generally like the maṅgalā bhoga of few lāḍus (ball of sweets). A curtain is drawn and Raṇachhodjī is supposed to eat them. There is no darśana at the time that any bhoga is placed before the idol when the doors are generally closed.

Having taken his "singār Bhoga" the idol is treated to his "singāra Ārti" and is ready to receive visitors. The temple remains open at the time of Rājabhoga—the mid-day meals of the god. After the Rāja-bhoga comes the rājabhoga Ārti and then the Mandir is closed in order that the god might have siesta.

The siesta lasts in Winter as well as in Summer for about 3 or 4 hours; and after the god is awake (so to say) comes the "Utthāpana" service. The Utthāpana bhoga is placed before the idol, and then the Mandir is opened and the Utthāpana Ārti commences. It remains open until evening when the Śayana bhoga is brought before the idol.

Before the "sakri bhoga" was instituted, this was the last bhoga, and the God was supposed to retire to bed. But now after this bhoga is over, the ārti is commenced and the temple-doors are kept open until the Sakri bhoga time. After the Sakri bhoga time is finished, there is no ārti, but the temple is kept open about a quarter of an hour for darśana and then it is closed for the night.

The site selected by Gopāla Tāmbvekar for the new temple was close to the Gomati-tank, and in spite of the fairly high plinth of the temple, the image was installed on such a high pedestal as to offer "Darśana" of the Ārti of the image to the devotees right from the "ghāṭa" of Daṅknāth, about 100 paces apart, because it was previously experienced that the mandir built by Abhesingh was neither so spacious nor did it offer sufficient room for "darśana" to people on festive occasions. It appears also

to have been a fact that on occasions of congregations of devotees, old and infirm people were even crushed to death !*

Once the imposing site of the temple commanded the view of the road facing the sacred reservoir, a new bazaar soon came into being, mainly catering to the religious and secular needs of pilgrims; and the locality developed into a new and important suburb of the town, which bears the name of "Gopālparu," in memory of Gopāla Rāo Tāmbvekar.

The development and prosperity of the village of Dākore gradually increased beyond calculation as the Lord of Laksmī had made it his abode, leaving the famous port of Dwārkā. §

It grew into a city as the whole paraphernalia also was transferred from Dwārkā to Dākore. § The waters of Gomati are held to be sacred by believers in Raṇachhoḍji, and both the tank and the temple of Daṅknāth Mahādeva are looked upon as part and parcel of the Sansthāna of Raṇachhodrājī. §§ It is noteworthy that there was no ill-will between the Śaivas and the Vaiṣṇavas. The same tolerance is in evidence at Paṇḍharpur where one has got first to bow to Mahādeva before he has darśana of Viṭhobā.

Dākore, has seen better days, after its acceptance as a pilgrim-centre for Viṣṇu worship in the right royal way. Accordingly a Veda-śālā, a Vyākaraṇa Pāthashālā, several endowments for doling out alms and cooked food to Sādhus—popularly called "Sadāvratas," a Bethaka of Hararāyaji Mahārāja† (late 17th century samvat) and the seat of Ichchārām Bhāṭṭji, the author of "Pradīpa"—a Sanksrit commentary on "Vallabhācārya's Aṇubhāṣya" on Vedānta Sūtras of the Vallabhite section of Vaiṣṇavas and several minor temples add to the glory of the

* See "Daṇakpur Māhātmya": "लोकयात्रिकसंघेषु दृष्ट्वा दुर्बलमर्दनम् ।"

§ "तत आरभ्य स ग्रामः पुरतुल्यो बभूव हि ।
हरिद्रा धनि नो जाता लक्ष्मीकान्तनिवासतः ॥ उं. पु. अ. ४ श्लो ३८.

§§ "द्वारका ग्रामरूपेण सरोरूपेण गोमती ।
तीर्थान्युदकरूपेण स्थितानि हरिधामनि ॥
सरोरूपेण या प्रोक्ता ङ्कग्रामे तु गोमती ।
तस्यां स्नानेन मनुजाः सद्यः शुद्धा भवन्ति हि ॥
गंगा तु भगवत्पादस्पर्शात् ख्याता महानदी ।
अस्यां तस्यै स्वयं कृष्णो द्वादशाहं निजेच्छया ॥" अ. १५-१६

† Giridharlālji (circa 1760-1795 Samvat) a descendant of Vallabhācārya records in his "120 Vacanāmṛtas" (in No. 64) that the image of Raṇachhoḍji, that was lying topsy-turvy having taken ill at Baroda King's actions in the niche of a wall was set right by Hararāyaji Mahārāja in early 17th century (i.e. long before the present temple was built) : It is not known who is meant by the 'King of Baroda.'

"श्री रणछोडरायजी श्री ठाकुरजी सो कृष्णवतारमें आप सेवा करते सो स्वरूप हे। सो बोडाणो भक्तके मनोरथ सिद्ध करिवेके लिये गुजरातमें डाकोर गाममें श्री द्वारकाजीसों पधारे। सो अधापताई विराजे हे। सो आपकी वार्ता अनके हे। सो लौकिकमें प्रसिद्ध हे। ओर बडोदाके राजासों रुसके भीतिमें ओंधे बिराजे। सो श्री हरिरायजीने मनायके सुधे पधराये। ओर श्री महाप्रभुजीको हुँ प्यरी हे। ओर तीन जातके सेवक सेवा करे हे। एक तो श्रीगाड़े ब्राह्मण तथा खेडावाल ब्राह्मण तथा तपोधना"

— श्रीणिरिधरलालजीके १२० वचनामृत : वचनामृत ६४, पृ. १६३.

town. The Māhātmya recounts a "Pañca-tīrthī" i.e., five abodes of gods round about the outskirts of Dākore and the noteworthy 13th century temple of Gālaveśvara or Galteśvara, on the confluence of the river Mahī and Galtī about 15 miles from Dākore deserve a passing mention. One notable saintly personality of Dākore—the late Haridāsaji Mahārāja is the disowned author of a classical Gujarāti religious work "Candrakānta," Parts I, II and III and a composer of devotional "stotras" and "bhajans" styled "Hariciñtanikā."

It is believed, the present Saracenic appearance of the turrets of the temple was responsible to the importation of its architect, one Sāhebo, from the South, a Mahomedan, who had good experience in building Hindu temples, however with Muslim variations,—as Hindu architects used to introduce Hindu motifs in designing Muslim Mosques and Rozās under the patronage of Gujarāt Sultāns. It is believed that Dākore temple was designed on the model of Pārvati Mātā temple in Poona built by Bālāji Bājirāo Peśvā sometime in 1746 A.D. Gopāla Tāmbvekar, having been a nobleman of the court of Peśvā, very probably got Dākore temple—at least its turrets visible in its front elevation—decorated in a mixed Hindu-Muslim style. The stylistic affinities between the Pārvati Mātā temple and the Dākore Viṣṇu temple can be best appreciated by the juxtaposition of photographs.

Along with this influence of Muslim architecture in Dākore temple, we cannot but refer to the established custom of the visit of the moveable image of Raṇachhodjī—the Gopāla Lālji—to the temple of Laxmiji in procession on the two Ekādaśis and the four Fridays of every month. (See the "Māhātmya," Adh. XIII, verses 43-45). Could it not be that in selecting the particular Friday as the privileged day for visits of Gopālālāji to Laxmiji's temple, the same Muslim influence might have been at work? In other words, one is tempted to look upon this bit of local tradition as smelling of an alien influence; because one is naturally struck at the selection having fallen on a Friday, the day universally adopted by Muslims for mass prayers, called "Jummā." Any way, the custom has been holding ground uninterruptedly even today, without one having been conscious of these under-currents.

On the site of the island formed to the west of the Gomati tank, Dāmāji Rāo Gāekwād had got constructed a ghāta, a bungalow and a well. These having gone out of repair, the custodian trustee of the place one Ayodhyādās Guru Jagannāth Dās Berāgi had petitioned on Vaiśākha Vad 8th, Samvat 1929 (1873 A.D.) to the Baroda Government to carry out repairs from State treasury as it formed part of the charitable endowment by the Gāekwāds. At the instance of this petition a clerk of the Thāsrā Māmlatdār's office carried on inquiries as to the ownership of the land in question. A map prepared on this occasion of the town of Dākore showing places round about the temple and the tank is very interesting and informative as it gives us an idea of this place 75 years ago. The petition is given in *Appendix F* for reference.

The Temple Committee appointed by the Bombay Government under orders of the Bombay High Court looks after the management of the temple, a representative of the Tāmbvekar family being an ex-officio member of the committee. It is to their credit that the working of the scheme has made the temple a spiritual—temporal power in Central Gujarāt, where devotees find all facilities to breathe a purer air on this earth.

APPENDIX A TO F

APPENDIX A*

Renewal of the Sanad of Dākore village by Mādhavrāo Ballāla Peśvā in favour of Gopāla Nāik Tāmbvekar, the grant having come down from the times of Mughal Emperors for the upkeep of the Viṣṇu temple at Dākore dated Śāka year 1691, 1826 Samvat, 1770 A.D.

श्री

राजश्री गोपाळ नाईक बीन लिंगापा नाईक

उपनाम तांबवेकर गोत्र काश्यप सूत्र अश्वलायन

गोसावि यासि,

खेवक माधवराव बल्लाळ प्रधान नमस्कार. सुमा सवेन मया व अलफ शाके १६९१ विगेधी नाम संवत्सरे. तुम्ही हुजूर कसे पुणे येथील मुक्कामी येऊन विदित केले की श्री देव डाकुरजी याचे पूजा नैवेद्याचे खर्चाबद्दल मोजे डाकूर प्रगणे ठासरे प्रांत गुजराथ हा गाव पेशजी पासून चालत आहे त्याप्रमाणे श्रीचे खर्चाबद्दल स्वामींनी कृपाळू होऊन गांव आपलेकडे करार करून दिल्याया आपण या गांवचा आकार होईल तो श्रीचे पूजा नैवेद्याकडे खर्च करित जाऊ म्हणोन विनंती केली. त्याजवरून मनास आणिता मोजे डाकूर प्रगणे ठासरे प्रांत मजकूर हा गाव पेशजी पासून श्रीचे पूजा नैवेद्याचे खर्चाबद्दल सरकारांतून चालत आहे त्या प्रमाणे मोजे मजकूर दरोबस्त कुल बाब कुल कानून हालीपटी व पेस्तरपटी खेरीज हाकदार व इमानदार करून श्रीचे खर्चाबद्दल तुम्हाकडे करार करून दिल्हा असे. तरी मोजे मजकूर तुम्ही आपले दुमाला करून घेऊन तुम्ही व तुमचे पुत्रपौत्रादि वंशपरंपरेने गांवचा आकार होईल तो श्री डाकुरजीचे पूजा नैवेद्याकडे प्रतिवर्षी खर्च करित जाणे. जाणिजे. छ १४ रमजान आझाप्रमाण. मोर्तब. (सिक्का)

APPENDIX B

Sanad of Kanajari village in Mahudhā Tālukā, Kairā District given by Sayājirāo Gāekwād I, to Gopāla Jagannāth Tāmbvekar for the pūjā, etc., of the newly built Viṣṇu temple dated śāka year 1691.

श्री द्वारकानाथ ।

राजश्री गोपाळ जगन्नाथ तांबवेकर

गोत्र काशियप सूत्र आश्वलायन

गोसाबी यासी ।

अखंडित लक्ष्मी आलंकृत राजमान्य स्नेहांकित सयाजीराव गायकवाड समक्षे वहादर दंडवत सुमा सवेन मया व अलफ व मोजे डाकूर प्रगणे ठासरे येथे श्रीजीचे नूतन देवालय करून श्रीची पुज्या सर्वा उत्तम प्रकारे व्हावी म्हणोन विनंती केली जे काही नूतन इनाम करून यावा त्याजवरून मनास आणितुं तुम्ही धर्मकृत्य करून श्रीचे सेवे करता या पुण्यकामीस आम्हचे

* True copies of these documents have been supplied to me from Baroda State Records Office, through the kind offices of Prof. C. V. Joshi, the Rājdaftardār and his clerk Mr. G. K. Gokhare, persons in charge of these archives. I am very much obliged to them.

दोलतांतील अंश श्रीस समर्पण केलें असता श्रेयस्कर जाणून मोजे कणझरी प्रगणे मोघे हा गांव दरोबस्त कुल बाब कुल कानूं देखील इनाम तिजाई खेरीज हाकदार व इनामदार करून जल, तरु, वृण, काष्ठ, पाषाण निधिनिक्षेप सहित सर्वमान्य मोजे मजकूर कृष्णार्पण करून हें दानपत्र भोगवटीयास करून दिले असे. तरी तुम्ही व तुमचे पुत्रपौत्रादी वंशपरंपरे करून गावचा उपभोग घेऊन स्वामीस व स्वामीच्या राज्यास कल्याण चिताने सुखरूप आसावे काळदेशवर्तमान करून गायकवाडाचे वंशीचे व हरकोणी या गांवाचा लोभ धरून उपद्रव करतील त्यास नर्कवास होईल शके १६९१. विरोधी नाम संवत्सरे कार्तिक शुद्ध ६ छ २ माहे रजब सही मोर्तब असे सिका.

APPENDIX C

- * Renewal of the grant of Kanajari village by Govindarāo Gāekwād.

श्री म्हाळसाकांत ।

राजेश्री गोपाळ उयंगंभाथ तांबवेकर

गोत्र काश्यप सूत्र आश्वलायन गोसावी ।

अखंडित लक्ष्मी आलंकृत राजमान्य स्नेहांकित गोविंदराव गायकवाड सेनाज्ञास खेळ समशेर बहादूर दंडवत सुमा अर्वा तीसेन मया व अलफ श्री डाकोरचे संस्थानचे खर्चा बद्दल मोजे कणझरी प्रगणे मोघे प्रांत गुजराथ हा गांव दरोबस्त तुम्हाकडे तीर्थस्वरूप राजश्री सयाजीराव गायकवाड समशेर बहादूर यांणी इनाम करून दिले त्या प्रमाणें गाव तुम्हाकडे चालत आहे । हाली तुम्ही पुणियाचे मुक्कामी विनंती केली की पुर्ववत प्रमाणें गावची पत्रें आपलें नांवाची करून द्यावी. त्यावरून पूर्वाल पत्रें व भोगवटा पाहून त्याप्रमाणें हाली हे इनामपत्र तुम्हांस करून दिले असे तरी तुम्ही व तुमचे पुत्र पौत्रादि वंशपरंपरेने गावचा उपभोग घेऊन श्रीची सेवा करून स्वामीचे राज्यास अभिष्ट चितोन सुखरूप राहाणे रवाना छ २६ रषीलाकर, बहुत काय लिहिणें हे विनंती. मोर्तब असे सिका.

APPENDIX D

Watch and ward to look after the donation of the dais of silver and gold sheets by the Gāekwāds.

श्री

अंक ३२९

सही

यादी चांदी व सोन्याचें सिंढासन अजमासे एक लक्ष दहा हजार रुपये खर्च पाषेतो खर्च होऊन डाकूर येथें श्रीकडे बसाविले आहे आणि त्याचे पत्रे व कलश वगैरे कोणी न उखळील ये पिशीचे दुरस्तीची तजवीज चांगली रितीन राहिली पाहिजे जाणून सरकारांतून एक कारकून व पांच शिपाई डाकूर येथे सरकारी इमारतीची जागा आहे तेथे राहतील, सबब महेरबानी करून या बाबे खेडे जिल्ह्याचे महेरबान माजिस्ट्रेट साहेब बहादूर यांस लिहून त्यांजकडून ठासऱ्याचे मामलेदार याजवर सदरहु प्रमाणें सरकारी कारकून व माणसे राहतील त्याचे बरदास्ती पिशी लिहून जाण्याचे व्हावे. सुमा सीतेन मयातेन व अरफ छ रमजान चैत्र शुद्ध ४ संवत १९१६ तारीख २६ माहे मार्च सन १८६० इसवी.

The official Note re : grants to Tāmbevekar.

श्री

यादी संस्थान श्री डाकूरनाथ येथील खर्चास श्री देवाकडे प्राचीन मोजे डाकूर हा गाव मोगलाई पासून चालू आहे. त्यास कैलासबासी गोपाल नाईक तांबवेकर गायकवाड सरकारास दिवाणगिरी करावयास पुण्याहून आले होते त्यांणी संस्थानाचा जीर्णोद्धार करून देवाकडे बांधिले त्याचे खर्चास,

- १ मोजे डाकूर पहिले पासून चालत होते त्या प्रमाणें पुण्यास राजश्री पंतप्रधान याजकडे विनंती करून कैलासबासी माधोराव बलाळ यांचे कारकिर्दीत गांवच्या सनदपत्रा राजमंडळच्या करून दिव्या त्यांत गोपाल नाईक यांनी वहीवट करून श्रीचे खर्चाबद्दल बगैरे बंदोबस्त उत्तम प्रकारे ठेवून चालवावे. या प्रमाणेनी निखालस कागद पत्र करून दिले.
- १ श्रीचा खर्च मोठा चालला पाहिजे जाणून सरकारांत विनंती केली त्याजवरून श्री देवाचे संस्थान व मशारनिलेहे दोलतीचे बहुत उपयोगी पडेल जाणोन प्रमणे मौढ्या पैकी मोजे कणसरी हा गांव कृष्णार्पण करून देऊन सनदपत्र दिले.

२

येणेप्रमाणें श्री देवाकडे खर्चास दोन गांव गोपाल नाईक यांणी करून घेतले त्या प्रमाणे अज पावेतो वहीवट मशारनिलेहेचे चिरंजीबाकडे चालला आहे.

APPENDIX F

The petition for repairs to Gäckwāds of the ghāṭa, bungalow and well on the bank of Gomati, dated 1873 A. D.

श्री

श्रीमंत सरकार सेनाखासखेल
समशेर बहादुर साहेबाचे

शुभवर्णिता बैरागी अयोध्यादास गुरू जगन्नाथदास रहेबासी श्री क्षेत्र डाकूर विज्ञापना एसि जे श्रीमंत महाराज दमाजीराव गायकवाड यांणी श्री गोमती मध्ये पश्चिमेच्या बाजूस बेट आहे तेथें महाराजांनी घाट, बंगला व कुवा बांधला आहे तो बहुत दिवस आजमासे शंभर सवाशे वर्षे जाहली जीर्ण काम जाहले आहे याकरिता आपण महाराज राजे धर्ममूर्ती सबब विज्ञापना करणें कीं आपलें गायकवाड सरकारचें नांव पुष्कळ ठिकाणी असे. परंतु ही जागा अशी आहे कीं त्या जागेंत असून समोर पूर्वेस श्री रणछोडराय महाराजांचे आरतीचें दर्शन पांचवी वेळचें होते अशी जागा उत्तम प्रतिची पाहून बांधिली आहे. ही जागा जीर्ण होऊन पडत चालली आहे. सबब त्या जागेचा जीर्णोद्धार करणार सरकार समर्थ आहे. आम्ही बैरागी श्रीची सेवा करून सरकारचे कल्याण इच्छून त्या जागेंत साधुसंत तीर्थवासी बैरागी राहत आहेत. करितां सरकारांनी धर्माचे कामाकडे लक्ष देऊन जीर्णोद्धार करणार सरकार धर्मी समर्थ आहेत सेवेची श्रुत होये हे विज्ञापन. मिती वैशाख वद्य ८ संवत् १९२९.

(१ खदी) अयोध्यादास गुरू जगन्नाथदास
खदी व खुद

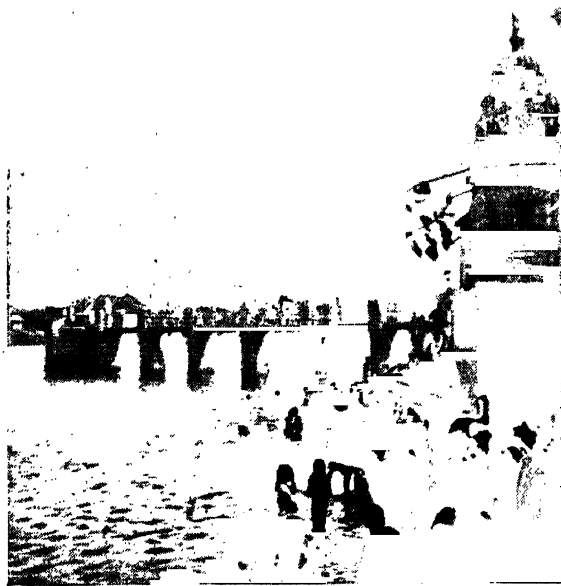


Temple at Dākore built by Gopāla Tāmbvekar in 1772 A. D.



Interior view of the
Dākore Temple

Spot where the image of
Ranchhodji lay hidden in
waters of Gomti tank, made
accessible by a bridge:
Temple Dāknath in view
(back elevation)

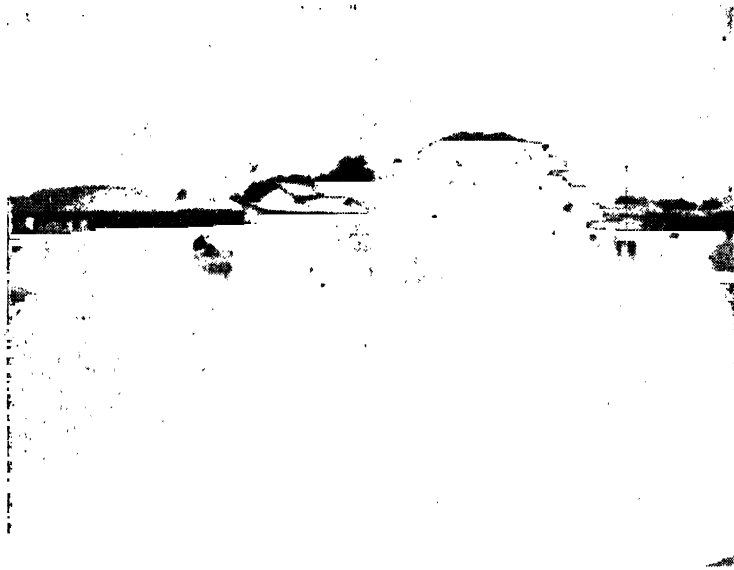




Temple at Dwarkā



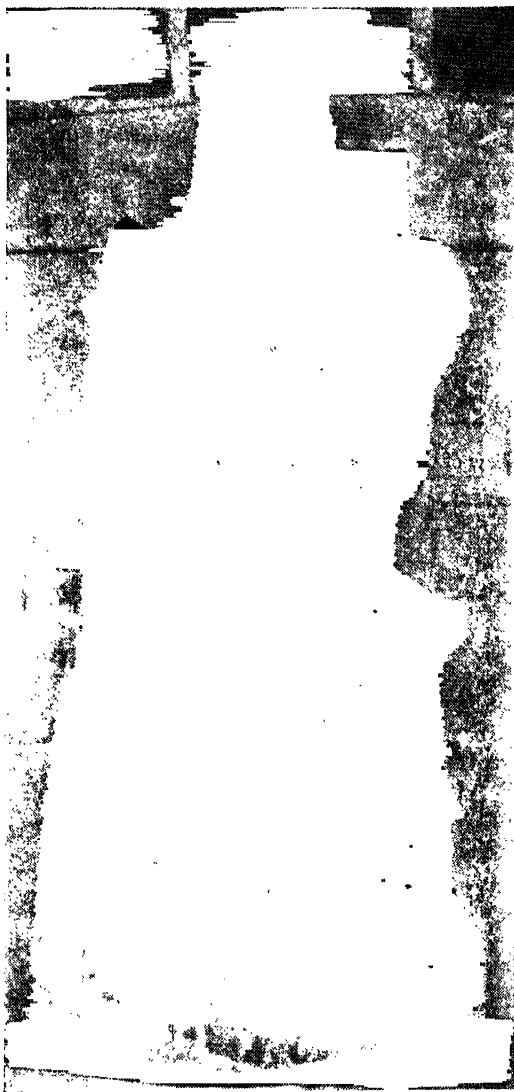
Ruins of Galesvara Temple on the confluence of the rivers Mahi and Gahni, about ten miles from Dākore



View of Gomti Lake as seen from the Ghāt of Daṁknāth

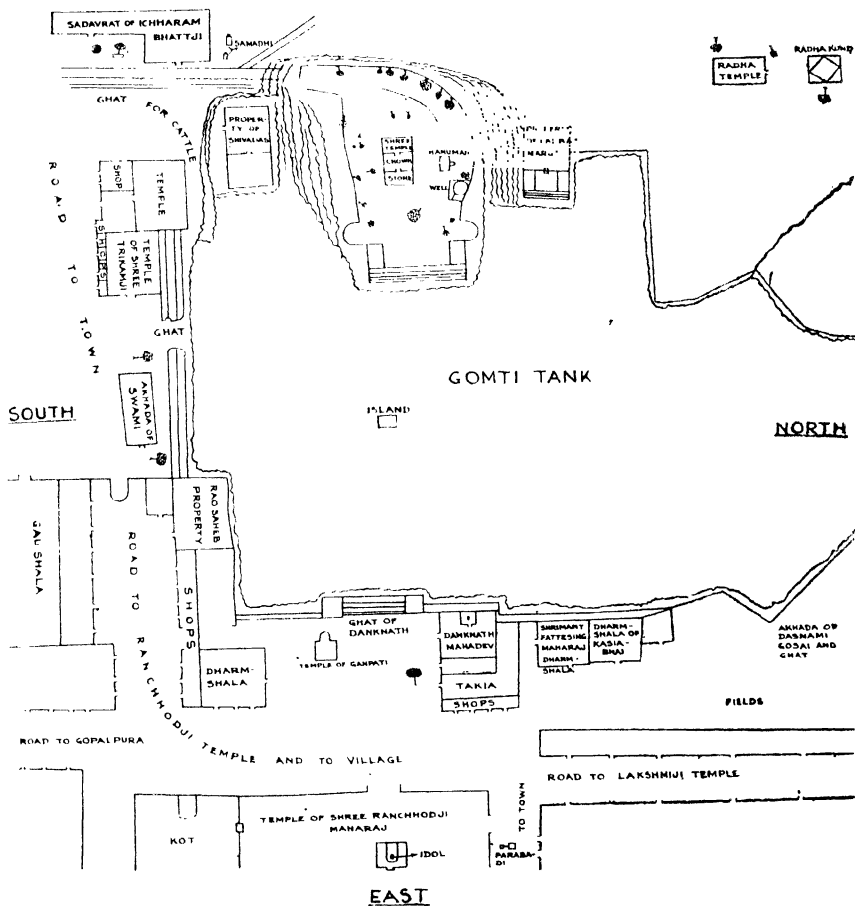


Images of Vajesingh Boḍāṇo and his wife Gangābai, worshipped in a temple



Trivikrama (PGCS) from Ghumli, sixty miles South of Jāmnagar

WEST
SITE PLAN OF GOMTI TANK & RANCHHODRAY TEMPLE
WITH SURROUNDINGS IN DAKORE TOWN IN 1870 A.D.





Inscription in the Kothi (office) of the Tāmbyekars (to the right side of the temple) recording the installation of the image of Viṣṇu in Samvat Year 1829 in the newly built temple at Dākore.—It also records the uncommon spires and turrets on the temple

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BOOK REVIEWS

Commodity Exchanges (With Special Reference to India in General and Bombay in Particular), by P. G. Salvi, M.A. The Co-operator's Book Depot, Bombay. Price Rs. 15.

COMMODITY exchanges constitute an important limb of the machinery for marketing agricultural produce. Such exchanges establish certain healthy trading practices and reflect correct price trends. When these have their influence on the agencies further down towards the producer, they are bound to create conditions beneficial to the agricultural industry. But such results will follow only if the commodity exchanges have reached an advanced stage of development and the marketing machinery from the producer to the exchange through which the commodity flows for being ultimately consumed or exported has more or less been perfected. Unfortunately none of these conditions obtains in our country to-day in the correct sense of the term. Except for one or two commodities marketing of agricultural produce in India is still done on the out-of-date lines and the machinery for the purpose is still imperfect and chaotic. Commodity exchanges have evolved in some of the important cities and towns of India, but when viewed from the stage their counterparts have reached in America and in the countries on the Continent, it should be said that they leave much to be desired. It is true that commodity exchanges essentially function in furtherance of the interests of the respective trades and help the primary producer only in an indirect way. But even this is denied to the Indian farmer due to the many imperfections but more particularly on account of the virtual absence of a systematic marketing agency for the primary products.

A few valuable studies on Indian exchanges connected with a couple of commodities have been made. The usual difficulty of research in this field is that connected with establishing necessary contacts. The literature on Indian commodity exchanges ill compares with that on similar bodies in the advanced countries. The Indian exchanges themselves do not appreciate the importance of research with the consequence that records for some of the most valuable data are not maintained while for others only disconnected accounts can be traced with difficulty. None of the exchanges maintains a regular research and statistical section. Not all publish even their annual reports. Thus except for the printed material about ruling prices for the use of members nothing useful in the field of research has been done by those who are primarily interested in the trade.

The author of the book has battled against all these difficulties with commendable success. He has marshalled all the available literature on commodity exchanges both in India and abroad. Through prolonged field work and sustained correspondence he has unearthed a good deal of valuable unpublished data on the subject.

The study begins with theoretical and historical backgrounds of the functions and development of commodity exchanges in general. The influence of commodity exchanges in other important countries on the evolution of similar institutions in our country is the high light of discussion. These are followed by the detailed account of the organisation and function of the commodity exchanges in Bombay. A comparative study of these exchanges come up in sequence. It has been shown that although the set up is basically uniform, each exchange varies according to the peculiar requirements of the trade which it serves. Their defects have been pointed out and suggestions have been offered for remedying them. The last two chapters on the theory of speculative prices and the effects of war on exchanges are illuminating and make valuable contribution on the subject.

A comprehensive work of this type embracing more than one commodity exchange of the country is perhaps the first of its kind and would prove of considerable interest and use to students as well as all those connected with the trade in primary commodities.

—M. B. DESAI

Bombay Finance (1921-1946), by T. M. Joshi. Published by the Gokhale Institute of Politics and Economics. Pp. 220. Price Rs. 7-8-0.

THIS book is an attempt to review the public finances of the Bombay Province during the period 1921-1946. The period has been divided into four main parts: (a) 1921-36, the period of Montague-Chelmsford reforms. This has been sub-divided into three distinct phases: (i) 1921-23 constituting a period of recession after the first World War; (ii) 1923-29, the era of recovery, rising prices, and increasing production and income; (iii) 1931-35, the depression period; (b) 1937-1940, the period of Provincial Autonomy and Popular Ministries; and (c) 1941-46 the era of war finance. The items of Provincial Revenue being inelastic, it is found that Provincial incomes were not very responsive to trade fluctuations; they were nevertheless amenable to wide economic movements.

Apart from its historical survey the most interesting portion of the book is the suggestions contained in it for the reformation of Provincial Finance—the introduction of an agricultural income tax, the levying of the Estate and Succession Duties as well as that of going slow with the Prohibition Policy. These will find many an echo among fellow economists. The author's suggestions however for assigning almost the whole revenue from income tax to the provinces cannot be justified on any of the principles of Federal Finance. To couple it, as the author has done, with the retention of the powers of income-tax legislation by the Federation does not improve the matters. Why should the Central Legislature, Government or staff care for the enhancement or efficient administration of a tax in the proceeds of which they have little share? True that prosperity is indivisible at least among the various layers of Governments and that their common aim is to serve the people. Even then under the best conditions the central legislature's and executive's enthusiasm will be lukewarm. The history of the proposals for the levy of an estate duty on non-agricultural property is an instance of this.

A great defect of the book seems that its suggestions for new taxes are not properly worked out, nor any inter-provincial comparisons made. While suggesting an agricultural income tax, the author could certainly have gone into the experience of the few provinces that have levied such a tax. The arguments for a general sales tax should have been elaborated, and worked out with due regard to the experience of other countries as well as an Indian Province like Madras which was the first to levy such a tax.

The book, however, is a welcome addition to the literature on Indian Public Finance.

—D. T. LAKDAWALA

Expansion of World Trade and Employment, by N. A. Sarma, M.A. "Commerce" Monographs on Current Topics, 1947. Pp. 118. Price Rs. 2-8-0.

AT a time when the preliminary discussions of 17 States which participated in the Geneva Conference to consider the draft of a Charter for the Expansion of World Trade and Employment, are being completed, and preparations for the Havana Conference, in which over 50 nations are participating, are being made, it would obviously be unfair to the reader or to the author (and even to the reviewer) to expatiate upon the thesis propounded in the book. Indeed, in India events have moved so fast that writers on economics so easily run risk of finding their conclusions getting somewhat out of date by the time their lines are printed. But whatever changes that have been witnessed in our country, as well as outside, since the completion of the monograph under review in January this year, the writer's theme, *viz.*, Expansion of World Trade and Employment is bound to arrest the reader's attention. The writer has indeed spread his canvas wide and has examined the draft proposals in the background of the fast changing scenes of international economic relationships. He concludes that they do not constitute a frank set of proposals, for he misses in them "a buoyant positive spirit and a practical determination to succeed in the translation of these sentiments into real policies pervading every page of the document." He devotes special attention to the case for under-developed economies in world trade and employment and in the proposed I. T. O. and pleads for liberty of action in the case of such countries as India and China; for India like Russia "is equally determined not to be deflected from her efforts for planned economic development." The success or failure of the proposed I. T. O. is to be judged by the standard, namely "we shall not have peace until economic conditions are bearable and backward economies are helped to go forward." It has indeed been a happy idea for the *Commerce* to bring out such a thoroughly readable monograph on a live-topical of the day.

—M. C. MUMSHI

LIST OF THESES

Table showing Ph.D. Graduates in Economics, Sociology and Geography from 1st July 1947 to 31st December 1947, with the titles of their theses, etc.

Name of the Candidate	Subject of the Thesis	Name of the Professor under whom the Candidate Worked	Name of the Institution
Ph.D.			
<i>Economics</i>			
Abhyankar, H. G.	Techniques, Methods and Procedures of Economic Planning in the U. K., the U. S. A., Germany and Soviet Russia with special reference to Post-War Conditions in India	Professor D. R. Gadgil	G. I. P. E.
Trivedi, A. B.	Wealth of Gujarat	Professor J. J. Anjaria	U. E. S.
Sayanna, V. V.	Land System of the Madras Province	Professor C. N. Vakil	U. E. S.
<i>Sociology</i>			
Agharkar, A. J.	Social Background of Physical Education with special reference to the Folk Dances of Maharashtra	Professor G. S. Ghurye	U. E. S.
<i>Geography</i>			
Abdul Hamid Khan	Geographical Conditions of Arab Sind During the Period of Arab Occupation	Dr. M. B. Pithawala	N. E. D.

BOOKS RECEIVED

Annual Report of the Indian Institute of International Affairs—for 1946-47.

Asia, Asian Relations Conference Souvenir Book.

Books on Asia.

Federal Problem in India, The, by D. R. Gadgil.

Food Problem in India, by B. L. Jalan.

Frontier Speaks, by Mohamnad Younus.

Gandhi, Tagore and Nehru, by K. R. Kripalani; Hind Kitabs, Ltd., Bombay.

God and Mammon, by Business Brothers.

Hind-Briton—no Nana Vyavakar, by J. C. Kumarappa.

India of My Dreams, by M. K. Gandhi, Edited by R. K. Prabhu.

Indian Polity, by R. V. Rao.

Introduction to Money, An, by K. Lalwani.

Joint Stock Companies Journal, 1947, 12th Anniversary Number.

Khedut ane Sahakar, by M. H. Shah.

Plea for the Mixed Economy, A, by M. R. Masani.

Problems of Accounting Valuation of Stock in Trade, by A. A. Fitzgerald; Published by the University of Queensland.

Regulations and Syllabuses of Examinations of the Commercial University, Lahore.

Storage and Inspection Courses held at Delhi from 7th-23rd October 1946; Government of India, Food Department.

Vikramaditya Problem, The, by Professor K. B. Vyas.

ACKNOWLEDGMENTS

Bikaner Bulletin

Commercial Journal

Eastern Anthropologist

Empire Cotton Growing Review

India Quarterly

Indian India

Insurance Herald

International Affairs

Journal of the Andhra History and Culture

Journal of the Indian Institute of International

Affairs

Majlis Telsancen

New India

Secretary

EXTENSIONS OF THE LIMIT THEOREMS OF CAUCHY AND CESÀRO

By V. S. HUZURBAZAR, M.A.

IN this paper the limit theorems of Cauchy and Cesàro in the theory of convergence of sequences are extended to any number of sequences. These extensions are applied in extending Abel's Theorem on multiplication of two series to multiplication of any number series.

Statements of Cauchy's and Cesàro's theorems as given in the usual text-books on infinite series are :—

(1) Cauchy's Theorem¹ :—

$$\text{If } a_n \rightarrow a \text{ then } \lim_{n} \frac{a_0 + a_1 + \dots + a_n}{n} = a$$

(2) Cesàro's Theorem² : If the sequences (a_n) and (b_n) converge to the limits a and b then

$$\lim_{n} \frac{a_0 b_n + a_1 b_{n-1} + \dots + a_n b_0}{n} = ab.$$

It should be noted that Cauchy's Theorem is obtained by writing $b_r = 1$ for all r in Cesàro's Theorem.

NOTATION: If $(a_n), (b_n), (c_n), \dots, (k_n)$ are p sequences then by $\sum_{r+s+t+\dots+z=n} a_r b_s c_t \dots k_z$,

we mean that the sum is taken over all non-negative integral values of r, s, t, \dots, z subject to the condition $r + s + t + \dots + z = n$. It may be remarked that the number of terms in the above sum is $\frac{(n+1)(n+2)\dots(n+p)}{p!}$.

In particular, $\sum_{r+s=n} a_r b_s = a_0 b_n + a_1 b_{n-1} + \dots + a_n b_0$,
and $\sum_{r=n} a_r = a_n$.

¹ Bromwich : Infinite series (1926), § 149 (p. 420); Bromwich calls this as Cauchy's first theorem.

² Bromwich : l.c., § 150 (p. 422).

Again by $\sum_{r+s+t+\dots+z=n} a_r$ we shall mean the sum to which

$\sum_{r+s+t+\dots+z=n} a_r b_s c_t \dots k_z$ reduces when $1 = b_s = c_t = \dots k_z$ for

all $0 \leq s \leq n, 0 \leq t \leq n, \dots, 0 \leq z \leq n$.

E.g. $\sum_{r+s+t=n} a_r b_s c_t = a_0 (b_0 c_n + b_1 c_{n-1} + \dots + b_n c_0) + a_1 (b_0 c_{n-1} +$

$\dots + b_{n-1} c_0) + \dots + a_{n-1} (b_0 c_1 + b_1 c_0) + a_n b_0 c_0$.

and $\sum_{r+s+t=n} a_r = (n+1) a_0 + n a_1 + (n-1) a_2 + \dots + 2 a_{n-1} + a_n$.

Similarly $\sum_{r+s=n} a_r = a_0 + a_1 + a_2 + \dots + a_n$.

In general $\sum_{r+s+t+\dots+p=n} a_r = \frac{(n+1)(n+2)\dots(n+p-1)}{(p-1)!} a_0 +$

$\frac{(n+1)(n+2)\dots(n+(p-2))}{(p-2)!} a_1 +$
 $+ \dots + a_n$.

Similarly by $\sum_{r+s+t+u=n} a_r b_s$ we shall mean the sum to

which $\sum_{r+s+t+u=n} a_r b_s c_t d_u$ reduces when $1 = c = d_u$ for all

$0 \leq t \leq n, 0 \leq u \leq n$.

Thus $\sum_{r+s+t+u=n} a_r b_s = (n+1) a_0 b_0 + n (a_0 b_1 + a_1 b_0) + \dots +$
 $(a_0 b_n + \dots + a_n b_0), r+s+t+u=n$.

In the above notation Cauchy's theorem may be stated as : If

$a_n \rightarrow a$ then $\frac{\sum_{r+s=n} a_r}{n} \rightarrow a$.

Cesàro's theorem becomes : If $a_n \rightarrow a$ and $b_n \rightarrow b$ then

$$\frac{\sum_{r+s=n} a_r b_s}{n} \rightarrow ab.$$

Extension of Cauchy's theorem :

If $a_n \rightarrow a$ then $\frac{\sum_{r+s+t+\dots+z=n} a_r}{n^{p-1}} \rightarrow \frac{a}{(p-1)!}$,

where p is the number of letters r, s, t, \dots, z .

*For brevity we shall demonstrate the theorem for the case $p=4$. The method employed will be seen to be perfectly general. We shall prove :

$$\text{If } a_n \rightarrow a \quad \text{then} \quad \frac{\sum_{r+s+t+u=n} a_r}{n^3} \rightarrow \frac{a}{3!}.$$

$$\text{LEMMA (1) : If } a_n \rightarrow o \quad \text{then} \quad \frac{\sum_{r+s+t+u=n} a_r}{n^3} \rightarrow o.$$

Given Σ , an arbitrarily small positive number, we can find an integer m such that $|a_n| < \Sigma$ when $n \geq m$. In particular $|a_m| < \Sigma$. Let k be the greatest of $|a_1|, |a_2|, \dots, |a_{m-1}|$.

$$\text{Now } \frac{\sum_{r+s+t+u=n} a_r}{n^3} = \frac{(n+1)(n+2)}{2} a_0 + \frac{n(n+1)}{2} a_1 \dots + \frac{(n-m+1)(n-m+2)}{2} a_m + \dots + a_n.$$

$$\therefore \left| \frac{\sum_{r+s+t+u=n} a_r}{n^3} \right| \leq \frac{(n+1)(n+2)}{2} |a_0| + \frac{n(n+1)}{2} |a_1| + \dots + \frac{(n-m+2)(n-m+3)}{2} |a_{m-1}| + \frac{(n-m+1)(n-m+2)}{2} |a_m| + \dots + |a_n|$$

$$\leq K \left[\frac{(n+1)(n+2)}{2} + \frac{n(n+1)}{2} + \dots \text{to } m \text{ terms} \right] + \Sigma \left[\frac{1.2}{2} + \frac{2.3}{2} + \dots \text{to } n-m+1 \text{ terms} \right],$$

$$\leq K [\lambda_1 n^2 + \lambda_2 n + \lambda_3] + \Sigma \left[\frac{1}{2} n^3 + \mu_1 n^2 + \mu_2 n + \mu_3 \right],$$

where the λ 's and μ 's depend on m only.

$$\therefore \left| \frac{\sum_{r+s+t+u=n} a_r}{n^3} \right| \leq K \left[\frac{\lambda_1 n^2 + \lambda_2 n + \lambda_3}{n^3} \right] + \Sigma \left[\frac{\frac{1}{2} n^3 + \mu_1 n^2 + \mu_2 n + \mu_3}{n^3} \right]$$

$$\leq K\Sigma + \Sigma, \text{ when } n \text{ is sufficiently large, } m \text{ being fixed, } \leq (K+1)\Sigma.$$

$$\therefore \left| \frac{\sum_{r+s+t+u=n} a_r}{n^3} \right| \rightarrow o.$$

Let now $a_n \rightarrow a$. Put $a_n = a + \alpha_n$ so that $\alpha_n \rightarrow o$. Then, writing a'_r for a before summation,

$$\begin{aligned}
& \frac{\sum_{r+s+t+u=n} a_r}{n^3} \\
&= \frac{\sum_{r+s+t+u=n} a'_r}{n^3} + \frac{\sum_{r+s+t+u=n} a_r}{n^3} \\
&= \frac{(n+1)(n+2)(n+3)}{3! n^3} a + \frac{\sum_{r+s+t+u=n} a_r}{n^3} \\
&\rightarrow \frac{a}{3!}, \text{ the second term tending to zero by lemma (1).}
\end{aligned}$$

Extension of Cesàro's theorem :

If $a_n \rightarrow a, b_n \rightarrow b, c_n \rightarrow c, \dots, k_n \rightarrow k$,
then $\frac{\sum_{r+s+t+\dots+z=n} a_r b_s c_t \dots k_z}{n^{p-1}} \rightarrow \frac{abcd \dots k}{(p-1)!}$,

where p is the number of sequences above.

Here again we shall establish the theorem when $p=4$, the method employed being perfectly general. We shall prove : If $a_n \rightarrow a, b_n \rightarrow b, c_n \rightarrow c, d_n \rightarrow d$ then

$$\frac{\sum_{r+s+t+u=n} a_r b_s c_t d_u}{n^3} \rightarrow \frac{abcd}{3!}.$$

First we shall establish a few lemmas :

LEMMA (2) : If $a_n \rightarrow o, b_n \rightarrow b, c_n \rightarrow c, d_n \rightarrow d$, then

$$\begin{aligned}
& \frac{\sum_{r+s+t+u=n} a_r b_s c_t d_u}{n^3} \rightarrow o. \quad \text{In particular} \quad \frac{\sum_{r+s+t+u=n} a_r b_s c_t}{n^3} \rightarrow o \quad \text{and} \\
& \frac{\sum_{r+s+t+u=n} a_r b_s}{n^3} \rightarrow o.
\end{aligned}$$

Sequences $(b_n), (c_n), (d_n)$ being convergent are bounded.

$\therefore |b_n| < k, |c_n| < k, |d_n| < k$ for all n .

$$\begin{aligned}
\therefore \left| \frac{\sum_{r+s+t+u=n} a_r b_s c_t d_u}{n^3} \right| & \leq \sum \left| \frac{a_r}{n^3} \right| |b_s| |c_t| |d_u| \\
& \leq K^3 \sum \left| \frac{a_r}{n^3} \right|
\end{aligned}$$

$\rightarrow o$, by extension of Cauchy's theorem since $|a_n| \rightarrow o$. Putting $du=1$ we have $\frac{\sum_{r+s+t+u=n} a_r b_s c_t}{n^3} \rightarrow o$, and putting

EXTENSIONS OF THE LIMIT THEOREMS OF CAUCHY AND CESARO

$c_t = 1, d_u = 1$, we get $\sum_{r+s+t+u=n} a_r b_s \rightarrow 0$.

LEMMA (3) : If $a_n \rightarrow a$ and $b_n \rightarrow b$ then

$$\frac{\sum_{r+s+t+u=n} a_r b_s}{n^3} \rightarrow \frac{ab}{3!}.$$

Put $a_n = a + \alpha_n$ where $\alpha_n \rightarrow 0$.

$$\begin{aligned} \text{Then } \frac{\sum_{r+s+t+u=n} a_r b_s}{n^3} &= \frac{a \sum_{r+s+t+u=n} b_s}{n^3} + \frac{\sum_{r+s+t+u=n} \alpha_r b_s}{n^3} \\ &\rightarrow \frac{ab}{3!}, \text{ since } \frac{\sum_{r+s+t+u=n} b_s}{n^3} \rightarrow \frac{b}{3!} \text{ and } \frac{\sum_{r+s+t+u=n} \alpha_r b_s}{n^3} \rightarrow 0 \end{aligned}$$

by lemma (2).

LEMMA (4) : If $a_n \rightarrow a, b_n \rightarrow b, c_n \rightarrow c$, then

$$\frac{\sum_{r+s+t+u=n} a_r b_s c_t}{n^3} \rightarrow \frac{abc}{3!}.$$

Put $a_n = a + \alpha_n$ where $\alpha_n \rightarrow 0$.

$$\begin{aligned} \text{Then } \frac{\sum_{r+s+t+u=n} a_r b_s c_t}{n^3} &= \frac{a \sum_{r+s+t+u=n} b_s c_t}{n^3} + \frac{\sum_{r+s+t+u=n} \alpha_r b_s c_t}{n^3} \\ &\rightarrow \frac{abc}{3!}, \text{ since } \frac{\sum_{r+s+t+u=n} b_s c_t}{n^3} \rightarrow \frac{bc}{3!} \text{ by lemma (3) and} \end{aligned}$$

$$\frac{\sum_{r+s+t+u=n} \alpha_r b_s c_t}{n^3} \rightarrow 0 \text{ by lemma (2), as } \alpha_n \rightarrow 0.$$

Let now $a_n \rightarrow a, b_n \rightarrow b, c_n \rightarrow c, d_n \rightarrow d$. Put $a_n = a + \alpha_n$ so that $\alpha_n \rightarrow 0$.

$$\begin{aligned} \text{Then } \frac{\sum_{r+s+t+u=n} a_r b_s c_t d_u}{n^4} &= \frac{a \sum_{r+s+t+u=n} b_s c_t d_u}{n^4} + \frac{\sum_{r+s+t+u=n} \alpha_r b_s c_t d_u}{n^4} \\ &\rightarrow \frac{abcd}{3!}, \text{ since } \frac{\sum_{r+s+t+u=n} b_s c_t d_u}{n^3} \rightarrow \frac{bcd}{3!} \text{ by lemma (4)} \end{aligned}$$

$$\text{and } \frac{\sum_{r+s+t+u=n} \alpha_r b_s c_t d_u}{n^4} \rightarrow 0 \text{ by lemma (2), since } \alpha_n \rightarrow 0.$$

Abel's theorem¹ on multiplication of two series :

Let $w_n = a_0 b_n + a_1 b_{n-1} + \dots + a_n b_0$. The series $\sum_{n=0}^{\infty} w_n$

is called the Cauchy product-series corresponding to the product of the two series $\sum_{n=0}^{\infty} a_n$ and $\sum_{n=0}^{\infty} b_n$. Abel's theorem states that if the three series $\sum a_n$, $\sum b_n$, $\sum w_n$, are convergent then $\sum_{n=0}^{\infty} a_n \times \sum_{n=0}^{\infty} b_n = \sum_{n=0}^{\infty} w_n$.

Usually two proofs of this theorem are found in the text books: the first¹ based on Cesàro's theorem (and hence independent of the use of functions) and the second² involving the use of Abel's continuity theorem on the power series.

Before proceeding to obtain an extension of Abel's multiplication theorem it is useful to observe two properties of our notation :

(1) The Cauchy product-series corresponding to the two series $\sum_{n=0}^{\infty} a_n$ and $\sum_{n=0}^{\infty} b_n$ is $\sum_{n=0}^{\infty} \sum_{r+s=n} a_r b_s$. The Cauchy product-series corresponding to the product of $\sum_{n=0}^{\infty} \sum_{r+s=n} a_r b_s$ and $\sum_{n=0}^{\infty} c_n$ is $\sum_{n=0}^{\infty} \sum_{r+s+t=u=n} a_r b_s c_t$.

So we shall say that the Cauchy product-series corresponding to the product of the three series $\sum_{n=0}^{\infty} a_n$, $\sum_{n=0}^{\infty} b_n$, $\sum_{n=0}^{\infty} c_n$ is $\sum_{n=0}^{\infty} \sum_{r+s+t=n} a_r b_s c_t$.

In general the Cauchy product-series corresponding to the product of the p series $\sum_{n=0}^{\infty} a_n$, $\sum_{n=0}^{\infty} b_n$, $\sum_{n=0}^{\infty} c_n$, , $\sum_{n=0}^{\infty} k_n$ is the series $\sum_{n=0}^{\infty} \sum_{r+s+t+\dots+z=n} a_r b_s c_t \dots k_z$.

(2) We have $\sum_0^n P_n = P_0 + P_1 + \dots + P_n = \sum_{r+s=n} P_r$, or in our notation $\sum_0^n \sum_{r+s=n} P_r = P_r$.

Again $\sum_0^n \sum_{r+s=n} P_r = (n+1) P_0 + nP_1 + \dots + P_n = \sum_{r+s+t=n} P_r$.

Similarly $\sum_0^n \sum_{r+s+t=n} P_r = \frac{(n+1)(n+2)}{2} P_0 + \frac{n(n+1)}{2} P_1 + \dots + P_n$.
 $r+s+t+u=n$

In general $\sum_0^n \sum_{r+s+t+\dots+y=n} P_r = \sum_{r+s+t+\dots+y+z=n} P_r$.

Extension of Abel's multiplication theorem : If all the series

$\sum_{n=0}^{\infty} a_n$, $\sum_{n=0}^{\infty} b_n$, $\sum_{n=0}^{\infty} c_n$, , $\sum_{n=0}^{\infty} k_n$, and

¹ Bromwich: l. c. (p. 91)

² Knopp: Infinite Series (1928), pp. 321-22; Whittaker and Watson: Modern Analysis (1935), p. 58.

$\sum_{n=0}^{\infty} \sum_{r+s+t+\dots+z=n} a_r b_s c_t \dots k_z$, are convergent then

$$\sum_{n=0}^{\infty} a_n + \sum_{n=0}^{\infty} b_n + \sum_{n=0}^{\infty} c_n + \dots + \sum_{n=0}^{\infty} k_n = \sum_{n=0}^{\infty} \sum_{r+s+t+\dots+z=n} a_r b_s c_t \dots k_z.$$

Without any loss of generality we shall demonstrate the theorem for the product of four series. We shall prove :

$$\sum_{n=0}^{\infty} a_n + \sum_{n=0}^{\infty} b_n + \sum_{n=0}^{\infty} c_n + \sum_{n=0}^{\infty} d_n = \sum_{n=0}^{\infty} \sum_{r+s+t+u=n} a_r b_s c_t d_u,$$

where all the series are convergent.

First proof (by extension of Cesàro's theorem and independent of the use of functions) :

$$\text{Let } A_n = a_0 + a_1 + \dots + a_n = \sum_0^n a_n; B_n = \sum_0^n b_n, C_n = \sum_0^n c_n, D_n = \sum_0^n d_n.$$

$$\text{Let } w_n = \sum_{r+s+t+u=n} a_r b_s c_t d_u \text{ and } \Omega_n = w_0 + w_1 + \dots + w_n = \sum_0^n w_n.$$

Let A, B, C, D, Ω , be the sums to infinity of the convergent series $\sum_0^{\infty} a_n, \sum_0^{\infty} b_n, \sum_0^{\infty} c_n, \sum_0^{\infty} d_n, \sum_0^{\infty} w_n$ so that $A_n \rightarrow A, B_n \rightarrow B, C_n \rightarrow C, D_n \rightarrow D$ and $\Omega_n \rightarrow \Omega$.

$$\begin{aligned} \text{Now } w_n &= \sum_{r+s+t+u=n} a_r b_s c_t d_u \\ &= \sum_{r+s+t+u=n} (A_r - A_{r-1}) (B_s - B_{s-1}) (C_t - C_{t-1}) (D_u - D_{u-1}) \\ &= \sum_{r+s+t+u=n} A_r B_s C_t D_u - 4 \sum_{r+s+t+u=n} A_r B_s C_t D_{u-1} + 6 \sum_{r+s+t+u=n} A_r B_s C_{t-1} D_{u-1} \\ &\quad - 4 \sum_{r+s+t+u=n} A_r B_{s-1} C_{t-1} D_{u-1} + \sum_{r+s+t+u=n} A_{r-1} B_{s-1} C_{t-1} D_{u-1}, \end{aligned}$$

$$\text{since } \sum_{r+s+t+u=n} A_{r-1} B_s C_t D_u = \sum_{r+s+t+u=n} A_r B_{s-1} C D_u = \dots \text{etc.}$$

$$\sum_{r+s+t+u=n} A_{r-1} B_{s-1} C_t D_u = \sum_{r+s+t+u=n} A_r B_{s-1} C_{t-1} D_u = \dots \text{etc.}$$

and so on.

We may write :

$$\begin{aligned} w_n &= \sum_{r+s+t+u=n} A_r B_s C_t D_u - 4 \sum_{r+s+t+u=n-1} A_r B_s C_t D_u + 6 \sum_{r+s+t+u=n-2} A_r B_s C_t D_u \\ &\quad - 4 \sum_{r+s+t+u=n-3} A_r B_s C_t D_u + \sum_{r+s+t+u=n-4} A_r B_s C_t D_u. \end{aligned}$$

It may be noted that the coefficients above are the same in the binomial expansion of $(1-x)^4$.

Or writing $Q_n = \sum_{r+s+t+u=n} A_r B_s C_t D_u$, we have

$$w_n = Q_n - 4 Q_{n-1} + 6 Q_{n-2} - 4 Q_{n-3} + Q_{n-4}.$$

$$\therefore \sum_0^n w_n = Q_n - 3 Q_{n-1} + 3 Q_{n-2} - Q_{n-3}$$

$$\text{i.e., } \Omega_n = Q_n - 3 Q_{n-1} + 3 Q_{n-2} - Q_{n-3}$$

$$\therefore \sum_0^n \Omega_n = Q_n - 2 Q_{n-1} + Q_{n-2}$$

$$\text{i.e., } \sum_{r+s=n} \Omega_r = Q_n - 2 Q_{n-1} + Q_{n-2}$$

$$\therefore \sum_0^n \sum_{r+s=n} \Omega_r = Q_n - Q_{n-1}$$

$$\text{i.e., } \sum_{r+s+t=n} \Omega_r = Q_n - Q_{n-1}$$

$$\therefore \sum_0^n \sum_{r+s+t=n} \Omega_r = Q_n$$

$$\text{i.e., } \sum_{r+s+t+u=n} \Omega_r = Q_n$$

$$\therefore \sum_{r+s+t+u=n} \Omega_r = \sum_{r+s+t+u=n} A_r B_s C_t D_u$$

$$\therefore \sum_{r+s+t+u=n} \Omega_r = \sum_{r+s+t+u=n} A_r B_s C_t D_u$$

The *L.H.S.* of the above equation tends to $\frac{\Omega}{3!}$ by the extension of Cauchy's theorem, since $\Omega_n \rightarrow \Omega$. The *R.H.S.* tends to $\frac{ABCD}{3!}$ in virtue of the extension of Cesàro's theorem, since $A_n \rightarrow A$, $B_n \rightarrow B$, $C_n \rightarrow C$, $D_n \rightarrow D$.

$$\therefore \frac{\Omega}{3!} = \frac{ABCD}{3!}$$

$$\therefore ABCD = \Omega$$

$$\therefore \sum_{n=0}^{\infty} a_n \times \sum_{n=0}^{\infty} b_n \times \sum_{n=0}^{\infty} c_n \times \sum_{n=0}^{\infty} d_n = \sum_{n=0}^{\infty} w_n = \sum_{n=0}^{\infty} \sum_{r+s+t+u=n} a_r b_s c_t d_u.$$

SECOND PROOF (by the use of Abel's continuity theorem on power series) :

The power series $\sum a_n x^n$, $\sum b_n x^n$, $\sum c_n x^n$, $\sum d_n x^n$ are all absolutely convergent when $|x| < 1$ because the series $\sum a_n$, $\sum b_n$, $\sum c_n$, $\sum d_n$ are convergent. Hence by Cauchy's Multiplication Theorem¹

$$\sum a_n x^n \times \sum b_n x^n = \sum_{n=0}^{\infty} \left(\sum_{r+s=n} a_r b_s \right) x^n,$$

and further the series on the right-hand side above is absolutely convergent when $|x| < 1$. Again by Cauchy's Multiplication Theorem

$$\sum_{n=0}^{\infty} \left(\sum_{r+s=n} a_r b_s \right) x^n \times \sum c_n x^n = \sum_{n=0}^{\infty} \left(\sum_{r+s+t=n} a_r b_s c_t \right) x^n,$$

and the series on the right-hand side above is also absolutely convergent when $|x| < 1$. Lastly, Cauchy's Theorem gives

¹ Bromwich, l. c. § 27 (p. 72).

$$\sum_{n=0}^{\infty} \left(\sum_{r+s+t=n} a_r b_s c_t \right) x^n \times \sum_{n=0}^{\infty} d_n x^n = \sum_{n=0}^{\infty} \left(\sum_{r+s+t+u=n} a_r b_s c_t d_u \right) x^n \dots (1)$$

when $|x| < 1$.

All the power series occurring in equation (1) above are convergent when $x=1$ and Abel's continuity theorem gives

$$\lim_{x \rightarrow 1-0} \sum_{n=0}^{\infty} a_n x^n = \sum_{n=0}^{\infty} a_n, \quad \lim_{x \rightarrow 1-0} \sum_{n=0}^{\infty} b_n x^n = \sum_{n=0}^{\infty} b_n, \dots$$

$$\text{and} \quad \lim_{x \rightarrow 1-0} \sum_{n=0}^{\infty} \left(\sum_{r+s+t+u=n} a_r b_s c_t d_u \right) x^n = \sum_{n=0}^{\infty} \sum_{r+s+t+u=n} a_r b_s c_t d_u.$$

Hence proceeding to the limit as $x \rightarrow 1-0$, equation (1) gives $\sum_{n=0}^{\infty} a_n \times$

$$\sum_{n=0}^{\infty} b_n \times \sum_{n=0}^{\infty} c_n \times \sum_{n=0}^{\infty} d_n = \sum_{n=0}^{\infty} \sum_{r+s+t+u=n} a_r b_s c_t d_u.$$

There is one important point to be observed in connection with the Extension of Abel's Multiplication Theorem. For simplicity we shall explain this point with reference to three series. The Cauchy product of the three convergent series $\sum a_n$, $\sum b_n$, $\sum c_n$ may be possible though at the same time the Cauchy product of $\sum a_n$ and $\sum b_n$ may fail. This happens when the series $\sum_{n=0}^{\infty} \sum_{r+s=n} a_r b_s$ is non-convergent¹ but the series

$$\sum_{n=0}^{\infty} \sum_{r+s+t=n} a_r b_s c_t \text{ is convergent. An interesting example illustrating}$$

this point has been constructed below :

First let us seek for two convergent series $\sum a_n$ and $\sum b_n$ such that the Cauchy product-series corresponding to their product is the oscillatory series $\sum (-1)^n$. We have

$$a_0 b_n + a_1 b_{n-1} + \dots + a_n b_0 = (-1)^n \dots (2)$$

$a_0 b_0 = 1$ and for convenience we may take $a_0 = b_0 = 1$. To determine a_n and b_n let us set

$$f(x) = \sum_{n=0}^{\infty} a_n x^n \text{ and } \phi(x) = \sum_{n=0}^{\infty} b_n x^n$$

$$\therefore f(x) \phi(x) = \sum_{n=0}^{\infty} (a_0 b_n + a_1 b_{n-1} + \dots + a_n b_0) x^n$$

$$= \sum_{n=0}^{\infty} (-1)^n x^n$$

$$= \frac{1}{1+x}$$

$$\therefore f(x) \phi(x) = \frac{1}{1+x}.$$

In this case $\sum_{n=0}^{\infty} \sum_{r+s=n} a_r b_s$ must be oscillatory, if non-convergent, as has been shown by Cesàro. See Bromwich, l. c. p. 91 and foot-note†.

Take $f(x) = \frac{1}{(1+x)^p}$ and $\phi(x) = \frac{1}{(1+x)^{1-p}}$, where $0 < p < 1$.

Then a_n and b_n are the coefficients of x^n in the expansions of $\frac{1}{(1+x)^p}$ and $\frac{1}{(1+x)^{1-p}}$ respectively.

$$\text{Thus } a_n = (-1)^n \frac{p(p+1)\dots(p+n-1)}{n!}, \quad a_0 = 1;$$

$$\text{and } b_n = (-1)^n \frac{(1-p)(2-p)\dots(n-p)}{n!}, \quad b_0 = 1.$$

The series $\sum_{n=0}^{\infty} a_n$, where a_n has the value obtained above, is certainly convergent with $\frac{1}{2^{1-p}}$ for its sum, because the binomial series corresponding to $(1+x)^{-p}$ is convergent since $-p+1 > 0$ *. Similarly the series $\sum_{n=0}^{\infty} b_n$, where b_n has the value given above, is convergent with $\frac{1}{2^{1-p}}$ as sum. Thus we have two convergent series $\sum a_n$ and $\sum b_n$; a_n and b_n having the values given above, for which the multiplication rule fails, giving the oscillatory series $\sum (-1)^n$.

Let now the series $\sum c_n$ be taken as $1 + \frac{1}{1 \cdot 2} - \frac{1}{2 \cdot 3} + \frac{1}{3 \cdot 4} - \dots$
 , so that $c_0 = 1$ and $c_n = (-1)^{n-1} \cdot \frac{1}{n(n+1)}$, $n > 1$.

The series $\sum c_n$ is convergent and has $2 \log 2$ for its sum. The Cauchy product-series corresponding to the product of the two series $\sum (-1)^n$ and $\sum c_n$ is the series

$$1 - \left(1 - \frac{1}{1 \cdot 2}\right) + \left(1 - \frac{1}{1 \cdot 2} - \frac{1}{2 \cdot 3}\right) - \left(1 - \frac{1}{1 \cdot 2} - \frac{1}{2 \cdot 3} + \frac{1}{3 \cdot 4}\right) + \dots,$$

i.e., $1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \dots$,

which is convergent as it has $\log 2$ for its sum. We now have by the extension of Abel's Multiplication Theorem,

$$\sum_{n=0}^{\infty} a_n \times \sum_{n=0}^{\infty} b_n \times \sum_{n=0}^{\infty} c_n = \sum_{n=0}^{\infty} (-1)^n \cdot \frac{1}{n+1} \quad \dots \dots \dots (3)$$

where a_n , b_n , c_n are as defined above. Equation (3) is easily verified as

$$\frac{1}{2^p} \times \frac{1}{2^{1-p}} \times 2 \log 2 = \log 2.$$

A special result may be obtained by taking $p = \frac{1}{2}$ in which case the Cauchy product-series corresponding to the square of $\sum a_n$ is $\sum (-1)^n$.

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KOLHAPUR.

* Bromwich, l. c. § 61 (p. 178).

SILT MECHANALYSER*

A New Silt Size Determinative Apparatus

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INTRODUCTION

IN his original and brilliant papers on "Stable Channels in Alluvium" (1), "Uniform Flow in Alluvial Rivers and Canals" (2) and "Regime Flow of Channels in Incoherent Alluvium" (3), Gerald Lacey of the United Provinces Irrigation Department defined the new concept of additional hydraulic variate 'f' and revised the fundamental flow equations for an average silt transporting channel in the light of this new concept. The formulæ provided a uniquely complete set of design equations for the use of irrigation engineers trying to attain regime flow of channels, which resulted in the desire to know more about the new variable, which he termed as 'Silt Factor.' Lacey furnished a preliminary descriptive explanation of 'f' and made it simply dependent upon the weighted mean diameter of the silt particles under transport. Different apparatuses, therefore, soon began to be designed at different places for collecting and testing samples of suspended and rolling silt in running water for the purpose of studying the chief quality characteristics of the transported material, particularly the silt charge and the silt grade and, as far as possible, to obtain a correct size distribution curve or curves of the silt particles by suitable mechanical processes of silt analysis (4).

PRESENT METHODS OF SILT ANALYSIS

The mechanical analyses of silts under transport in connection with the Regime Flow of Channels have become indispensable to find out the weighted mean diameter (w.m.d.) value, termed as 'm' value, for substitution in the Lacey Formulæ and a number of mechanical processes of silt analysis have come in vogue. Usually very fine silts in suspension are analysed into 9 fractions by the well-known Sedimentation Method and the I. M. M. Standard Sieves (5) and fine and coarse bed silts are analysed into 20 fractions by the Puri Siltometer (6). The percentage weight of each silt fraction analysed by either of the two methods is multiplied by average diameter size of that fraction and the sum of these products divided by 100 yields 'm' value of that silt sample. Thus the present method of silt analysis and working out of 'm' values is rather tedious and time consuming and one person can analyse only 8 silt samples in a working day of 7 hours. The Optical Lever Siltometer (7) is too delicate and elaborate for the mass work of silt analyses *in situ*. A Hydrometer

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(8) was designed for estimating total solids in irrigation waters. But it estimated fine suspended silt and not the coarse rolling or deposited silt. A Capillarimeter (9) has lately been evolved to measure capillary pull of a silt sample and to correlate the same with its weighted mean diameter value. Whereas the Puri Siltometer, the Optical Lever Siltometer and the Capillarimeter are not portable, the measurement of capillary pull by means of the Capillarimeter is tedious and delicate because air locks inside the long connecting rubber tube have to be removed before testing each silt sample. Besides a slight jerk in the sliding movement of the burette breaks capillaries abruptly and the test fails. The working of the Capillarimeter, therefore, is neither simple nor rapid and it entails mathematical calculations to work out w.m.d. value of a silt sample. Further it may be remarked that the results of silt analysis by one mechanical process are not comparable to those obtained by another process as shown below :

TABLE I

Showing Weighted Mean Diameter Values of 25 Silt Samples obtained by the present 3 different mechanical processes of Silt Analysis, viz : by the Sedimentation and I. M. M. Standard Sieves, the Puri Siltometer and the Capillarimeter.

Silt Nos.	w.m.d. by the Sedimen- tation I.M.M. Standard Sieves	w.m.d. by Puri Silto- meter	w.m.d. by Capillari- meter
1	2	3	4
	mm	mm	mm
1	0.0985	0.156	0.175
2	0.1075	0.174	0.198
3	0.1165	0.176	0.198
4	0.1241	0.178	0.250
5	0.1355	0.180	0.255
6	0.1391	0.182	0.258
7	0.1575	0.202	0.275
8	0.2018	0.231	0.330
9	0.1755	0.221	0.322
10	0.1838	0.213	0.302
11	0.2585	0.252	0.352
12	0.3282	0.274	0.370
13	0.2875	0.264	0.355
14	0.3085	0.278	0.362

TABLE I—(continued)

Silt Nos.	w.m.d. by the Sedimen- tation I.M.M. Standard Sieves	w.m.d. by Puri Silto- meter	w.m.d. by Capillari- meter
1	2	3	4
	mm	mm	mm
15	0.1175	0.175	0.198
16	0.1285	0.178	0.200
17	0.1255	0.176	0.198
18	0.1475	0.185	0.225
19	0.1385	0.177	0.198
20	0.1870	0.222	0.285
21	0.2518	0.251	0.350
22	0.1875	0.223	0.225
23	0.2455	0.265	0.365
24	0.3555	0.305	0.395
25	0.3085	0.285	0.385

It is very significant that for the same silt sample, the w.m.d. value obtained by means of Puri Siltometer is uniformly higher than that obtained by the Sedimentation and I. M. M. Standard Sieves ; and further w.m.d. values arrived at by means of the Capillarimeter are more than those obtained by Puri Siltometer. However it will be seen that though the 'm' value obtained by means of different methods varies considerably for the same silt sample, yet each method is yielding comparative w.m.d. values for different silt samples consistently. Consequently a standard process of mechanical analysis of fine and coarse silts must needs be evolved, and in the meantime, there is an urgent need of a simple and portable mechanical device by means of which weighted mean diameter of silts can be measured directly and rapidly in the laboratory as well as in the field.

THEORETICAL

If a tube contains a silt sample to be tested for its 'm' value and is connected by means of an air tight rubber tubing to the upper end of a burette containing water which is allowed to run for a fixed time interval from the lower burette end, the volume of water so displaced would be proportional to the volume of air that would pass through the silt column. The volume of air that would pass through the silt column in turn would depend on the size of silt particles so far as it affects pores in the silt column. Therefore fine silts would displace less volume of water and coarse silts would displace more volume of water since the former would admit less air to pass through it on account of its smaller pores and the latter would admit more air to pass through it on account of its larger pores.

EXPERIMENTAL

A glass tube having an internal diameter of 1.25 cms was taken and 100 silts of different textures were filled in it to 66 cms, 37.5 cms and 20 cms heights. The volumes of water displaced in scheduled time intervals were recorded. The samples were gently tapped at the time of filling them in the glass tube till the level of silt column was more or less stable at the requisite height. The volume of water displaced by air through silt columns of different heights are given in the following table:—

TABLE II

Showing volumes of water displaced by air through silt columns of 66 cms, 37.5 cms and 20 cms heights in the scheduled time intervals.

Silt Numbers & Texture	Volume of water displaced by air through:		
	Silt column of 20 cms height in 15 seconds	Silt column of 37.5 cms height in 30 seconds	Silt column of 66 cms height in 30 seconds
	Average of four readings 2	Average of four readings 3	Average of four readings 4
1			
	cc	cc	cc
1. Fine	24.5	35.2	38.0
2. Fine	24.0	35.0	38.2
3. Fine	24.2	35.2	38.6
4. Fine	24.1	35.6	38.4
5. Fine	24.5	35.4	38.5
6. Fine	24.8	36.0	38.2
7. Fine	24.9	36.2	38.4
8. Fine	24.6	36.2	38.3
9. Fine	25.5	36.6	38.5
10. Fine	22.0	34.0	38.0
11. Fine	25.5	37.0	36.6
12. Fine	25.4	37.4	36.0
13. Fine	25.6	37.2	35.4
14. Fine	25.7	37.5	35.2
15. Fine	25.5	37.6	35.4
16. Fine	26.0	38.4	31.9
17. Fine	26.5	39.5	31.7
18. Fine	26.0	39.0	32.4
19. Fine	26.4	39.4	31.4
20. Fine	25.2	39.0	32.0
21. Fine	24.0	37.3	37.0
22. Fine	25.4	37.4	37.1
23. Fine	24.8	37.2	37.4
24. Fine	25.5	37.0	37.5
25. Fine	25.0	37.0	37.5
26. Fine	26.0	36.2	37.8
27. Fine	26.4	36.4	37.9
28. Fine	26.5	36.6	37.0
29. Fine	26.2	36.4	37.6
30. Fine	26.0	36.5	37.5
31. Fine	24.2	36.6	37.3
32. Fine	24.8	36.4	37.1
33. Fine	24.5	36.5	37.5
34. Fine	24.0	36.4	37.6
35. Fine	28.0	37.6	37.2
36. Fine	29.0	38.8	37.6
37. Fine	28.6	38.8	38.5
38. Fine	28.8	38.8	37.5
39. Fine	28.5	38.6	37.4
40. Fine	28.2	38.4	37.2
41. Fine	27.2	37.8	37.9
42. Fine	27.2	37.6	37.8
43. Fine	27.0	37.6	38.4
44. Fine	27.5	37.8	37.9
45. Fine	29.5	38.0	39.0
46. Coarse	32.5	40.0	40.0
47. Coarse	32.5	40.1	40.0
48. Coarse	32.2	40.1	39.9

TABLE II—(continued)

Silt Numbers & Texture	Volume of water displaced by air through:		
	Silt column of 20 cms height in 15 seconds	Silt column of 37.5 cms height in 30 seconds	Silt column of 66 cms height in 30 seconds
	Average of four readings 2	Average of four readings 3	Average of four readings 4
1			
	cc	cc	cc
49. Coarse	32.6	40.2	40.6
50. Coarse	34.5	42.0	42.1
51. Coarse	35.4	44.0	36.2
52. Coarse	36.5	43.9	35.5
53. Coarse	36.0	44.0	36.2
54. Coarse	36.2	44.6	36.4
55. Coarse	35.0	43.0	36.8
56. Coarse	34.2	42.3	40.8
57. Coarse	34.5	42.1	40.6
58. Coarse	34.6	42.2	41.0
59. Coarse	34.8	42.2	41.2
60. Coarse	34.0	42.0	41.1
61. Coarse	34.6	42.2	39.8
62. Coarse	34.5	42.2	39.9
63. Coarse	34.2	42.1	39.6
64. Coarse	34.4	42.2	40.0
65. Coarse	34.0	42.0	39.9
66. Coarse	34.6	42.0	39.8
67. Coarse	34.5	42.1	40.0
68. Coarse	34.2	42.0	39.6
69. Coarse	34.4	42.1	39.4
70. Coarse	34.8	42.2	39.8
71. Coarse	35.6	43.0	43.8
72. Coarse	36.4	43.5	43.4
73. Coarse	36.0	42.9	43.4
74. Coarse	36.8	43.0	43.6
75. Coarse	36.4	42.8	43.5
76. Coarse	32.8	42.0	40.9
77. Coarse	33.5	42.1	41.4
78. Coarse	33.4	42.0	41.4
79. Coarse	33.8	42.6	41.0
80. Coarse	33.6	42.8	41.6
81. Coarse	32.8	42.4	41.5
82. Coarse	33.2	42.2	41.2
83. Coarse	32.8	42.4	42.0
84. Coarse	31.9	42.0	42.2
85. Coarse	32.6	42.5	42.4
86. Coarse	32.4	42.6	42.2
87. Coarse	32.0	42.0	42.2
88. Coarse	34.2	42.0	42.6
89. Coarse	34.0	42.6	42.2
90. Coarse	34.0	42.5	42.2
91. Coarse	34.8	42.5	41.9
92. Coarse	34.5	42.4	42.5
93. Coarse	38.2	45.6	41.9
94. Coarse	38.6	45.4	41.7
95. Coarse	38.3	45.6	41.9
96. Coarse	38.4	45.5	42.0
97. Coarse	35.8	43.2	43.2
98. Coarse	36.2	43.4	43.5
99. Coarse	36.2	43.2	43.4
100. Coarse	36.0	43.0	43.2

Note :—The results of individual readings vary from the average within 0.2 cc, variation upto 0.5 cc being very rare.

It will be seen from the foregoing table that the volumes of water displaced through different heights of silt columns by air are more for coarse silts than for fine silts as demanded by the theory. The volumes of water displaced by air through 20 cms silt column in 15 seconds, however, vary more truly as the silt texture and the volume readings are markedly different for different silt grades. The same is not very true in the case of volumes of water displaced by air through 37.5 cms and 66 cms silt column as there is no marked variation in spite of some obvious correlation. Therefore 20 cms height of silt column and 15 seconds time interval for the displacement of water have tentatively been fixed for actually testing a silt sample.

Next it was attempted to study correlation between the volumes of displaced water by the present method and the w.m.d. values obtained by means of the I.M.M. Standard Sieves, the Puri Siltometer and the Capillarimeter.

TABLE -III

Showing volumes of displaced water by the present method and the w.m.d. values obtained by means of the I.M.M. Standard Sieves, the Puri Siltometer and the Capillarimeter.

Silt Nos.	Volume of water displaced by air through 20 cms silt column in 15 seconds	w.m.d. by the Standard I.M.M. Sieves	w.m.d. by the Puri Siltometer	w.m.d. by the Capillarimeter
1	2	3	4	5
	cc	mm	mm	mm
1	23.0	0.1055	0.1112	0.190
2	24.0	0.1075	0.1182	0.198
3	24.2	0.1075	0.1111	0.198
4	24.5	0.1078	0.1121	0.202
5	24.5	0.1075	0.1122	0.222
6	24.8	0.1094	0.1115	0.198
7	24.9	0.1069	0.1563	0.230
8	25.0	0.1099	0.1652	0.245
9	25.4	0.1009	0.1052	0.205
10	25.4	0.1171	0.1435	0.225
11	25.8	0.1179	0.1532	0.230
12	26.0	0.1179	0.1558	0.235
13	26.2	0.1181	0.1598	0.240
14	26.4	0.1182	0.1643	0.255
15	26.5	0.1212	0.1722	0.248
16	27.0	0.1291	0.1781	0.250
17	27.2	0.1391	0.1820	0.250
18	27.5	0.1288	0.1780	0.255
19	27.8	0.1298	0.1755	0.250
20	28.0	0.1291	0.1799	0.250
21	28.6	0.1241	0.1780	0.250
22	29.0	0.1553	0.1798	0.250
23	29.5	0.1588	0.1875	0.255
24	30.0	0.1551	0.1889	0.255
25	30.5	0.1669	0.1998	0.265
26	30.9	0.1871	0.2115	0.280
27	31.2	0.1981	0.2206	0.305
28	31.8	0.2031	0.2265	0.305
29	32.0	0.2023	0.2363	0.310
30	32.2	0.1989	0.2398	0.315
31	32.5	0.1753	0.2425	0.320
32	33.0	0.1959	0.2565	0.325
33	33.4	0.2001	0.2599	0.330
34	33.5	0.2032	0.2610	0.335
35	33.7	0.2031	0.2625	0.330
36	34.0	0.1981	0.2598	0.330

TABLE III—(continued)

Silt Nos.	Volume of water displaced by air through 20 cms silt column in 15 seconds	w.m.d. by the Standard I.M.M. Sieves	w.m.d. by the Puri Siltometer	w.m.d. by the Capillarimeter
1	2	3	4	5
	cc	mm	mm	mm
37	34.4	0.2078	0.2599	0.335
38	34.5	0.1839	0.2130	0.303
39	34.5	0.1902	0.2480	0.325
40	34.5	0.1988	0.2206	0.305
41	34.5	0.2031	0.2556	0.355
42	34.9	0.2188	0.2658	0.355
43	35.2	0.2201	0.2699	0.356
44	36.0	0.2308	0.2698	0.355
45	36.0	0.2308	0.2710	0.358
46	36.4	0.2582	0.2740	0.370
47	36.5	0.2618	0.2800	0.330
48	36.5	0.2618	0.2850	0.380
49	37.1	0.2588	0.2850	0.385
50	38.4	0.2728	0.3050	0.390

Evidently the w.m.d. value of a silt sample by the different methods of mechanical analysis is not the same. The 'm' value obtained by the Puri Siltometer is more than that by the I. M. M. Standard Sieves and less than that by the Capillarimeter and is, more or less, average of the two values. The volume of displaced water truly varies according to the 'm' value of a silt sample obtained by either method of silt analysis mentioned above. However the volumes of displaced water are correlated with the w.m.d. values obtained by means of the I. M. M. Standard Sieves much more truly and consistently.

The writer in his "A Critical Note on Puri Siltometer" (10) has shown that the results of silt analysis by the Puri Siltometer are erratic for a silt sample on repetition at the same or different working temperatures resulting in variations of 'm' value of the same silt sample at different times. The I. M. M. Standard Sieves, on the other hand, fractionate coarse bed silts and sands according to their physical size faithfully and the results of silt analyses are constant for the same sample and comparable for different samples. This has further been confirmed by the present series of experiments and, for this reason, there is very close correlation between such constant physical test as the volumes of displaced water by the present new process and the w.m.d. values arrived at by the I. M. M. Standard Sieves rather than those obtained by the Puri Siltometer. Another striking feature of the Siltograph No. 2 is that the volumes of displaced water are correlated more regularly with the w.m.d. values of 0.15 mm and above and not below 0.15 mm. This is quite in agreement with the fact that the Puri Siltometer is suitable for fractionating coarse silts and sands and not fine silts (11).

Lastly an effort was made to find out if there was any correlation between volume of 50 grammes of a silt, its Apparent Specific Gravity, Real Specific Gravity, Total Porespace, the Volumes of Displaced Water by the present method and the 'm' value. The comparative statement of the results obtained is given below:

TABLE IV

Showing volumes of 50 grammes of 25 silt samples, their Apparent Specific Gravity, Real Specific Gravity, Total Porespace, the Volumes of Displaced Water and the w.m.d. values by the I.M.M. Standard Sieves, the Puri Siltometer and the Capillarimeter.

Silt Nos.	Volume of water displaced by air through 20 cms silt column in 15 seconds	Volume of 50 gms of silt	Apparent Specific Gravity	Real Specific Gravity	Pore Space	w.m.d. by I.M.M. Sieves	w.m.d. by Puri Siltometer	w.m.d. by Capillarimeter
1	2	3	4	5	6	7	8	9
	cc	cc			%	mm	mm	mm
1	23.0	27.0	1.84	2.99	38.5	0.1055	0.1112	0.190
2	24.0	27.5	1.81	2.97	39.0	0.1075	0.1182	0.198
3	24.8	32.0	1.56	2.65	41.1	0.1094	0.1115	0.198
4	25.4	30.0	1.66	2.75	39.6	0.1171	0.1435	0.225
5	26.0	32.0	1.56	2.62	40.5	0.1179	0.1558	0.235
6	26.5	32.0	1.56	2.67	41.5	0.1212	0.1722	0.248
7	27.2	33.0	1.51	2.64	42.8	0.1391	0.1820	0.250
8	28.0	32.0	1.56	2.68	41.8	0.1291	0.1799	0.250
9	28.6	30.0	1.66	2.83	41.3	0.1241	0.1780	0.250
10	29.0	30.5	1.64	2.78	41.5	0.1553	0.1798	0.250
11	29.5	30.0	1.66	2.84	41.6	0.1588	0.1875	0.255
12	30.0	31.0	1.61	2.75	41.4	0.1551	0.1889	0.255
13	30.5	31.5	1.59	2.72	41.5	0.1669	0.1998	0.265
14	31.2	31.0	1.61	2.76	41.6	0.1981	0.2206	0.305
15	32.0	31.0	1.61	2.77	41.8	0.2023	0.2363	0.310
16	32.5	30.0	1.66	2.72	39.0	0.1753	0.2424	0.320
17	33.0	31.5	1.59	2.79	43.0	0.1959	0.2565	0.325
18	33.5	31.0	1.61	2.83	43.1	0.2032	0.2610	0.335
19	34.0	32.5	1.54	2.69	42.8	0.1981	0.2598	0.330
20	34.4	31.0	1.61	2.80	42.5	0.2078	0.2599	0.335
21	35.2	33.0	1.51	2.65	43.0	0.2291	0.2699	0.356
22	36.0	33.0	1.51	2.70	44.0	0.2308	0.2710	0.355
23	35.5	31.0	1.61	2.80	42.5	0.2618	0.2800	0.330
24	37.1	32.0	1.56	2.75	43.5	0.2588	0.2850	0.385
25	38.4	32.0	1.56	2.77	43.6	0.2728	0.3050	0.390

Obviously the volume of air varies with the porespace characteristically.

TECHNIQUE

A silt sample to be tested for its 'm' value is filled in the silt tube (Fig. 1) having 20 cms height and 1.25 cms internal diameter. If the silt tube has got vertical air tube at the bottom as shown in Fig. 2, a strainer of fine mesh has to be placed in the bottom of the silt tube. But if the silt tube has got blind bottom and is provided with a side air tube as shown in Fig. 1, the strainer is not necessary. The silt sample is tapped gently till the level of the silt column is stable at the top of the silt tube. The lower end of the silt tube is connected by means of an air tight rubber tube to the upper end of a 50 cc burette containing water at 0 cc mark. A stop watch is worked and the lower end of the burette is opened simultaneously. The water is allowed to run for 15 seconds and the volume of water displaced by air through 20 cms silt column is recorded. The w.m.d. value corresponding to the volume of displaced water is quickly and directly read off from the Siltograph showing w.m.d. values versus the volumes of displaced water.

SILTOGRAPH

For the purpose of preparing a Siltograph in the first instance, about 100 silts of known w.m.d. values by any *accepted mechanical process* of silt analysis are tested by the Silt Mechanalyser. A Siltograph is constructed showing the w.m.d. values versus the volumes of displaced water. Knowing, therefore, the volume of displaced water of an unknown sample by the Silt Mechanalyser, its w.m.d. value can be obtained conversely from the Siltograph readily.

Thus the actual testing of a silt sample to assess its weighted mean diameter by the Silt Mechanalyser takes only half a minute and very large numbers of silts can be tested in the laboratory as well as in the field conveniently. Its additional advantage is that the w.m.d. values of a number of silts obtained by any popular or accepted method of silt analysis can be plotted against the volumes of displaced water by the present process and a relative Siltograph prepared.

PRACTICAL RESULTS

The w.m.d. values read off from the Siltographs by the present process were compared with those obtained by the I.M.M. Standard Sieves, the Puri Siltometer and the Capillarimeter and the practical results gathered are given below :

Showing comparative w.m.d. values obtained by the Silt Mechanalyser, the I.M.M. Standard Sieves, the Puri Siltometer and the Capillarimeter

Silt Nos.	Volumes of displaced water by Silt Mechanalyser	w.m.d. values read off from Siltograph 1	w.m.d. values by I. M. Standard Sieves	w.m.d. values read off from Siltograph 2	w.m.d. values by Puri Siltometer	w.m.d. values read off from Siltograph 3	w.m.d. values by Capillarimeter
1	2	3	4	5	6	7	8
	cc	mm	mm	mm	mm	mm	mm
1	23.2	0.1025	0.1075	0.1050	0.1155	0.1825	0.2015
2	23.7	0.1050	0.1012	0.1175	0.1205	0.1900	0.1925
3	24.1	0.1050	0.1135	0.1250	0.1375	0.1925	0.2025
4	24.6	0.1075	0.1172	0.1300	0.1452	0.2025	0.2225
5	24.8	0.1100	0.1184	0.1325	0.1415	0.2050	0.2225
6	25.1	0.1100	0.1195	0.1375	0.1391	0.2100	0.2000
7	25.6	0.1125	0.1112	0.1500	0.1712	0.2150	0.2355
8	25.7	0.1125	0.1095	0.1500	0.1665	0.2200	0.2400
9	25.9	0.1175	0.1205	0.1525	0.1675	0.2225	0.2125
10	26.3	0.1200	0.1294	0.1575	0.1691	0.2250	0.2150
11	26.6	0.1225	0.1215	0.1625	0.1712	0.2300	0.2550
12	26.7	0.1225	0.1265	0.1675	0.1715	0.2325	0.2115
13	27.0	0.1275	0.1255	0.1700	0.1725	0.2350	0.2555
14	27.4	0.1300	0.1281	0.1750	0.1775	0.2425	0.2504
15	27.5	0.1300	0.1292	0.1750	0.1795	0.2425	0.2456
16	27.8	0.1350	0.1365	0.1800	0.1825	0.2475	0.2505
17	28.2	0.1375	0.1382	0.1850	0.1855	0.2550	0.2612
18	28.9	0.1450	0.1555	0.1950	0.1895	0.2650	0.2525
19	29.0	0.1450	0.1455	0.1950	0.1962	0.2650	0.2592
20	29.1	0.1450	0.1385	0.1950	0.1975	0.2650	0.2652
21	29.3	0.1500	0.1555	0.1975	0.1895	0.2700	0.2685

RESULTS—(continued)

Silt Nos.	Volumes of displaced water by Silt Mechanalyser	w.m.d. values read off from Siltograph 1	w.m.d. values by I. M. Standard Sieves	w.m.d. values read off from Siltograph 2	w.m.d. values by Puri Siltometer	w.m.d. values read off from Siltograph 3	w.m.d. values by Capillarity-meter
1	2	3	4	5	6	7	8
	cc	mm	mm	mm	mm	mm	mm
22	29.5	0.1500	0.1562	0.2000	0.2055	0.2725	0.2720
23	29.8	0.1550	0.1655	0.2050	0.2112	0.2750	0.2765
24	30.3	0.1600	0.1584	0.2100	0.2202	0.2825	0.2812
25	30.5	0.1600	0.1652	0.2150	0.2255	0.2850	0.2786
26	30.6	0.1600	0.1678	0.2150	0.2222	0.2850	0.2865
27	30.7	0.1625	0.1554	0.2175	0.2215	0.2900	0.2885
28	31.0	0.1675	0.1561	0.2200	0.2212	0.2950	0.2965
29	31.5	0.1725	0.2223	0.2250	0.2275	0.3000	0.3065
30	31.8	0.1750	0.2025	0.2300	0.2345	0.3050	0.3152
31	32.1	0.1775	0.1775	0.2325	0.2345	0.3075	0.3155
32	32.4	0.1825	0.1822	0.2350	0.2345	0.3150	0.3252
33	32.7	0.1850	0.1912	0.2400	0.2412	0.3200	0.3255
34	32.9	0.1900	0.2031	0.2450	0.2475	0.3225	0.3305
35	33.2	0.1950	0.1845	0.2475	0.2481	0.3250	0.3265
36	33.5	0.1975	0.1845	0.2500	0.2505	0.3300	0.3333
37	33.9	0.2050	0.2082	0.2575	0.2555	0.3350	0.3415
38	34.0	0.2050	0.2225	0.2575	0.2582	0.3350	0.3425
39	34.3	0.2100	0.2312	0.2600	0.2625	0.3400	0.3372
40	34.9	0.2175	0.2020	0.2675	0.2695	0.3500	0.3415
41	35.4	0.2250	0.2222	0.2725	0.2695	0.3550	0.3645
42	35.9	0.2300	0.2355	0.2775	0.2762	0.3625	0.3555
43	36.3	0.2375	0.2325	0.2800	0.2855	0.3675	0.3875
44	36.8	0.2450	0.2552	0.2850	0.2855	0.3725	0.3615
45	37.1	0.2475	0.2562	0.2900	0.2925	0.3750	0.3950
46	37.7	0.2600	0.2625	0.2950	0.2912	0.3900	0.3875
47	37.9	0.2625	0.2605	0.3000	0.3055	0.3925	0.4005
48	38.1	0.2625	0.2595	0.3000	0.3045	0.3925	0.3915
49	38.2	0.2675	0.2685	0.3025	0.3112	0.3950	0.3915
50	38.5	0.2725	0.2755	0.3050	0.3115	0.4000	0.3915

It will be seen from the foregoing table that the w.m.d. values obtained from Siltographs 1, 2 and 3 by means of the Silt Mechanalyser are in close agreement with those obtained by means of the I. M. M. Standard Sieves, the Puri Siltometer and the Capillarity-meter.

NECESSARY PRECAUTIONS

The following necessary precautions must be taken while working and testing silts with the Silt Mechanalyser :

1. The connection joining the silt tube and the burette of the Silt Mechanalyser must be perfectly air tight since air that passes through the silt column alone should displace water in the burette.

2. As the displacement of water from the lower end of the burette depends first upon the exclusion of air from the empty parts of the Silt Mechanalyser between the lower end of the silt column in the Silt tube and water level in the burette, the sizes of various parts of the Silt Mechanalyser must be of the same dimensions at the time of examining silts of unknown 'm' value as at the time of testing silts of known 'm' value for the purpose of preparing a Siltograph. For the same reason, the level

of water in the burette should be at 0cc mark at the time of testing each silt sample of known as well as unknown 'm' value.

3. As the volume of water displaced is proportional to the volume of air that would pass through a constant height of silt column, the compaction of a silt sample in the tube would naturally affect the pore-space and consequently the passage of air. But if the sample is gently tapped at the time of filling it in the silt tube, the compaction is fairly uniform and constant as soon as the level at the top of the silt tube is stable on mild tapping.

4. The opening in the lower end of the burette must be wider than that at the lower end of the silt tube and upper end of the burette so that the rate of flow of water would be dependent exclusively on the volume of air that would pass through the lower end of the silt tube and enter the burette.

FURTHER SCOPE OF WORK

It is proposed to pursue further experiments with the Silt Mechanalyser at the Central Waterways Irrigation and Navigation Research Station, Poona on the following lines :

1. At least 100 silt samples of different grades will be analysed by Optical Lever Siltometer, the Puri Siltometer, the Capillarimeter, the I. M. M. Standard Sieves and the present Silt Mechanalyser to discover which mechanical process of silt analysis should be adopted as standard.

2. The influence of compaction on porespace and, therefore, on the passage of air and displacement of water will be studied with a view to standardise the manner of filling a sample in the silt tube.

3. The possibility of further reducing the height of 20 cms silt tube and increasing the time interval for the displacement of water will be examined to standardise the same.

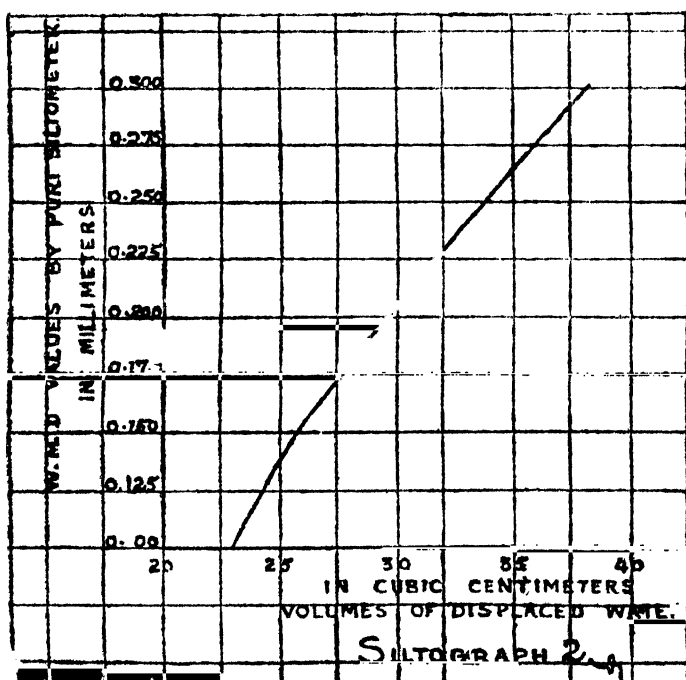
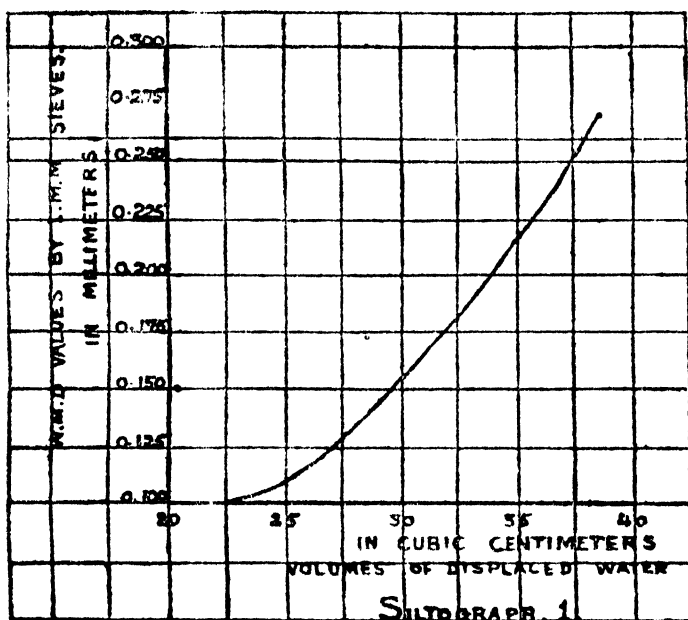
4. To study the influence of temperature on the volume of displaced water.

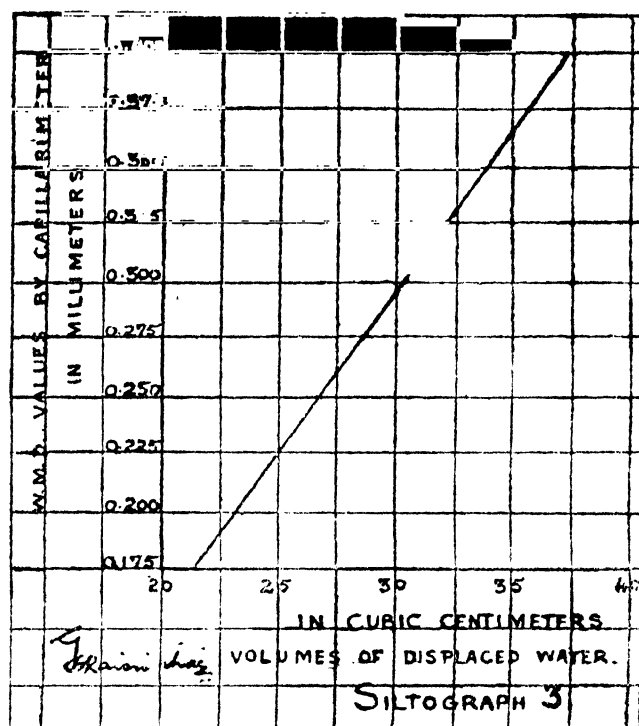
RESUME

The present methods of silt analysis have been reviewed and a new and simple mechanical process of silt analysis has been evolved by devising the Silt Mechanalyser to assess the w.m.d. value of a silt sample directly and rapidly. The construction and working of the new silt size determinative apparatus have been described and the merit of the new method has been pointed out. Besides necessary precautions to be taken while testing silts by the present new apparatus have been explained and further scope of experiments with it has been outlined.

CONCLUSION

The Silt Mechanalyser described herein was evolved and the experimental work with regard to it was carried out in the Irrigation Research Laboratory of the Sind Public Works Department. The writer takes this opportunity to express his deep sense of gratitude to K. K. Framji, M.B.E., I.S.E., the then Executive Engineer, Development and Research Division and now Director of the Central Waterways, Irrigation and Navigation Research Station, Poona, who very kindly granted all possible facilities to carry out the experimental work in the Laboratory and the Division in his charge.





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AUTOMATIC MUSICAL ACCOMPANIMENT TO VOCAL MUSIC

(Patent applied for)

By H. V. MODAK

THE basis of Indian music differs from that of European music. In case of Indian music the pitch of the note produced by all the accompanying instruments is exactly the same as that of the note sung by the singer. And so the method involving the following principle to provide automatic musical accompaniment to vocal music was thought of.

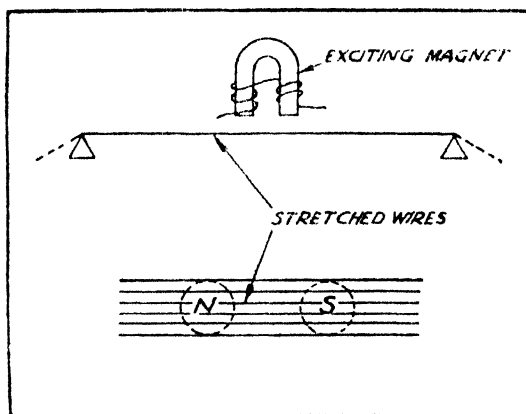
The Principle is that notes of the vocal music are picked up by a microphone, are amplified, and the amplified current is used to excite in some way or other, a series of stretched wires tuned to the notes of the musical scale. Thus when a note is sung, only the wire in tune will vibrate and will provide the necessary accompaniment.

EXPERIMENTAL

Three different methods, for exciting the wires have been tried and described below.

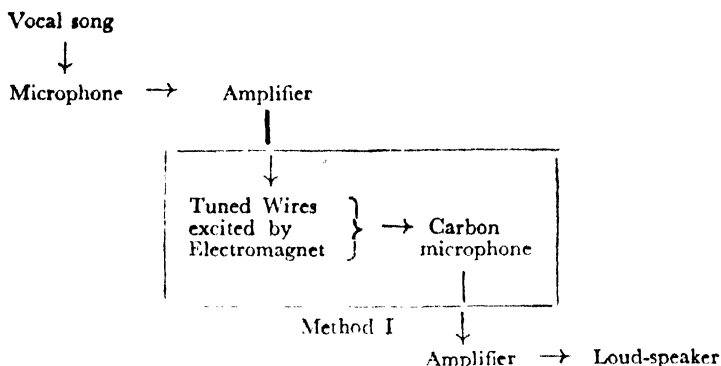
METHOD I

This is similar to Bell's telephone receiver, in which a number of stretched steel wires tuned to different notes replace the vibrating diaphragm. The wires are very close to each other (about 1 m.m. apart) and are in one plane. Two coils are wound on the poles of a strong horse-shoe magnet, which is kept close relative to steel wires, so that the wires are permanently pulled to a certain extent. The coils are connected to the out-put transformer of the amplifier, when the current from the amplifier flows through



Method I

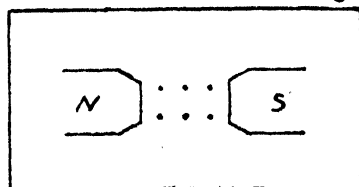
the coils it changes the pull on the wires, which are thus set into vibrations. The wire in tune naturally vibrates to a greater extent. However the reproduction from the wires was found to be so feeble that to get proper idea of it, further amplification was needed. This is obtained by using a second microphone, amplifier and a loud-speaker. This microphone should remain unaffected by the magnetic field exciting the wires and so a carbon microphone was used. The wires and the carbon microphone were enclosed in a felt-lined box. The arrangement can be represented as follows :



It is found that the note given by the loud-speaker is not a pure instrumental musical note. The reason is that when a certain note is sung the wire in tune vibrates more, but in addition other wires not in tune also vibrate to some extent and all together produce background noise. This is clear from the fact that if only one wire in tune with the note sung, is kept while others are removed, then the note emitted is much purer instrumental musical note. And if all wires not in tune are retained, while the wire in tune is only removed then the note emitted is a distorted vocal note, mixed with many sounds. On the whole this method has been found quite unsatisfactory.

METHOD II

The wires are excited by passing the out-put current through them and placing a part of them in a very strong magnetic field. The out-put current is passed through all the wires connected in series, and the field is obtained from a strong electromagnet connected to a D. C. source. In the actual experiment six brass wires were used and

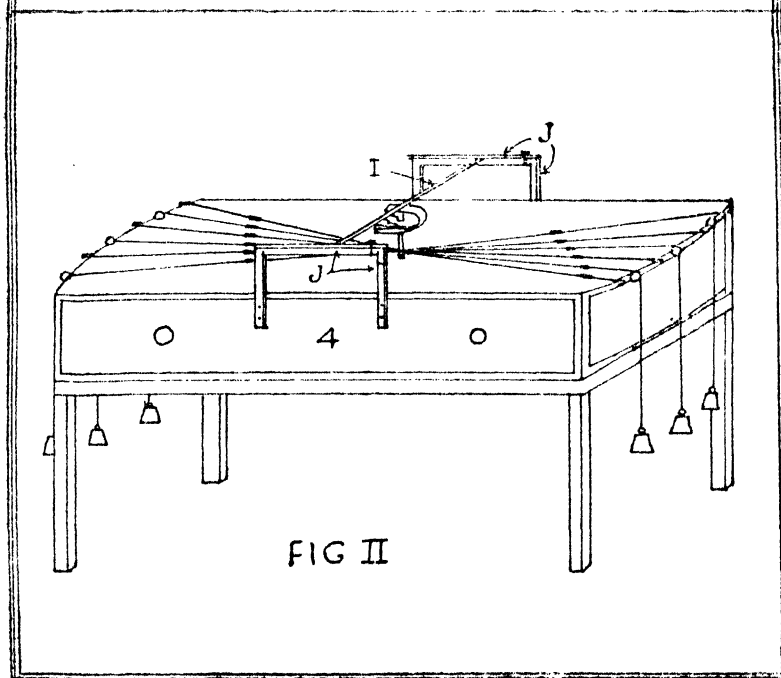
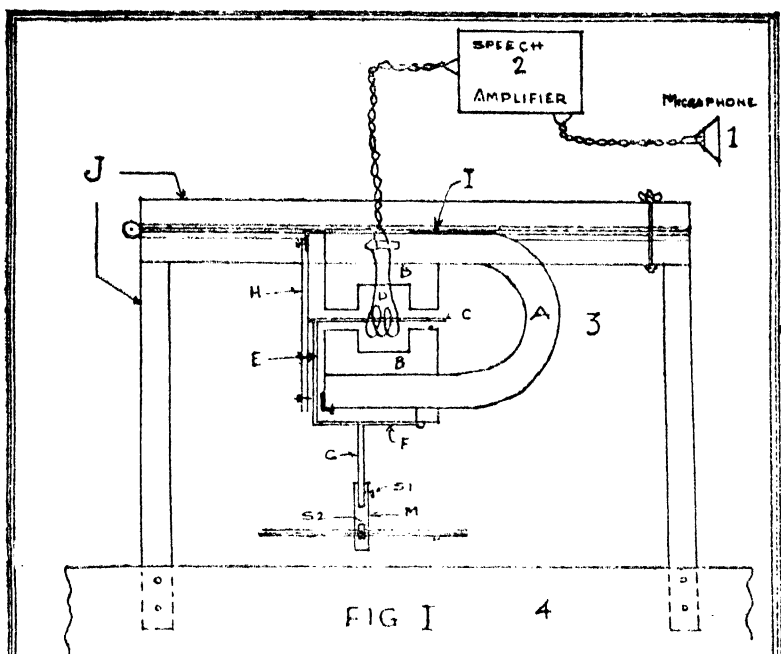


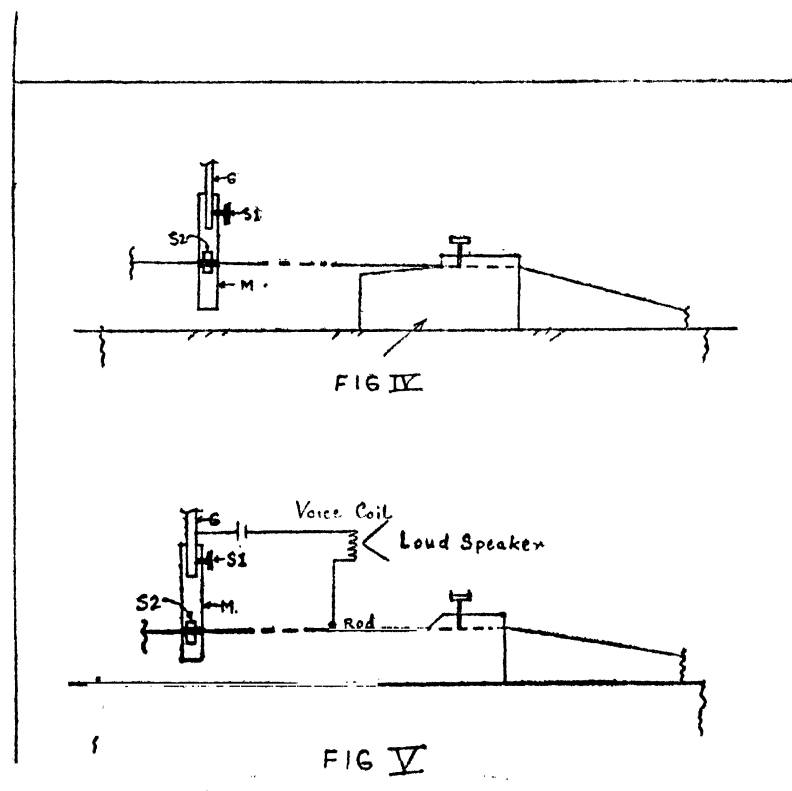
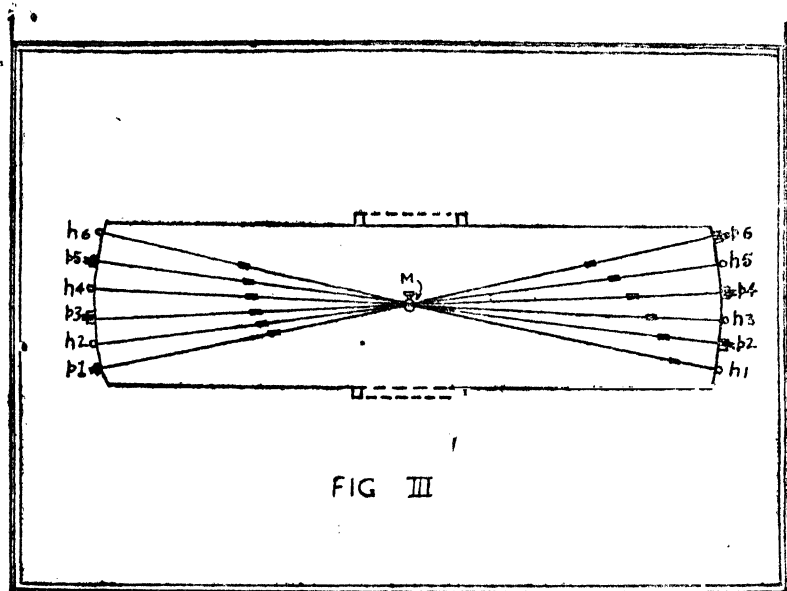
Method II

were tuned to the notes of the song (which was composed of six different notes only). The wires were stretched in two layers between the poles of the magnet as shown in the diagram. Satisfactory results were obtained, and although some background noise was present, it was feeble in comparison with the note emitted by the wire in tune.

METHOD III

This method consists in first transforming the electrical vibrations into mechanical ones and then transmitting them to the wires. The following arrangement has been found efficient and satisfactory and provides a good sort of accompaniment.





The arrangement is shown in the accompanying diagrams (Fig. 1 to 3). The notes sung are picked up by the microphone, are amplified and the amplified current is passed through a motor of balanced armature type (as is used in case of reed type of loud-speakers). An amplifier of about 20 watts out-put is sufficient to provide necessary accompaniment to the singer. A heavy permanent magnet 'A' is fitted with the laminated slotted pole pieces 'B' 'B'. A short reed 'C' is held midway between these pole pieces by a stiff spring in such a way that the reed can rock about its centre point and return to its zero position after displacement. A soft rubber piece 'H' is also joined to the armature 'C' so as to provide a non-reactive resistance. Surrounding this vibratory reed and embedded in pole slots is a winding 'D' of several turns. Fastened to the outer end of the armature is the stiff rod 'E' which is joined to the outer end of the lever 'F'. Joined to this lever is a stout rod 'G' which is connected to the mass 'M' kept in suspension by symmetrically stretched wires which pass through a small hole in 'M'. The vibrating motor is fitted to the rigid frame of the sounding board through felt packing so that the vibrations of the body of the motor are not transmitted to the board. For convenience, wires are strained by equal loads, and are tuned to different notes on each side of 'M' by adjusting the positions of the supporting bridges, the length of vibration in each case being from 'M' to the corresponding bridge. Thus 'M' becomes one nodal point for all wires. When a certain note is sung the wire in tune practically absorbs and radiates all the energy available.

The note emitted is strong enough to mask any resulting background noise. As 'M' is a nodal point, other wires practically remain stationary. The piece of rubber absorbs all extra energy and the use of it gives a pure instrumental musical note.

It is found that the quality of the reproduced note mostly depends on the nature of the wire, sounding board, and the supporting bridges, etc., and not on the quality of the note sung. If different vowels are pronounced to give the same note then no appreciable difference between the qualities of the reproduced notes is perceived by ear. This is also shown by taking simultaneous photographs of the wave form of the note sung and note reproduced. (Photographs I and II)

In the following are described three adjustments which can easily be adapted and produce different musical effects.

ADJUSTMENT I

A very pleasant effect is produced if the wires are made to strike—which is quite possible as the amplitude is more than one cm.—rods or tubes of the same natural frequencies as that of wires. In the actual experiment tuning forks were held below every wire. (Photograph III)

ADJUSTMENT II (Fig. IV)

Another effect is obtained by using long bridges with a small angle of inclination so that various upper harmonics are produced when the wire vibrates and strikes the bridge continuously. (Photograph IV)

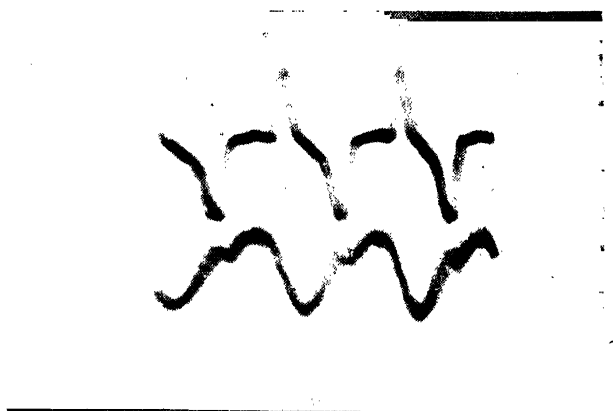
ADJUSTMENT III (Fig. V)

A metal rod is fixed above the wires so that the wires strike it when vibrating and thus a circuit is completed through the voice coil of a loud-speaker. A wire of frequency 'n' strikes the rod n times and thus the note emitted by the loud-speaker is of the same pitch, but of different quality. (Photograph V). The same method can provide a number of novelties. Say for example a separate contact-maker can be used for every different wire and the current can be passed to excite correspondingly tuned another wire or a reed fitted at the mouth of air cavity resonator.

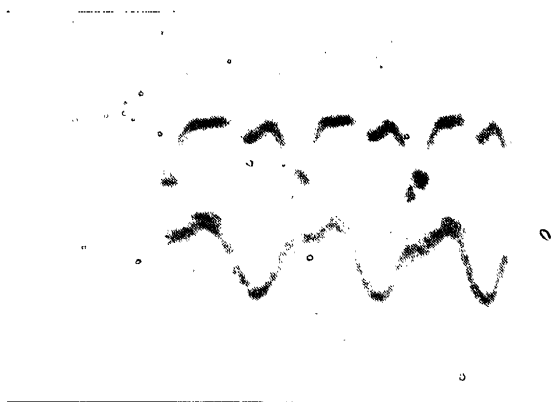
USE OF CLAMPED FREE REEDS (Fig. VI)

Use of vibrating reeds in place of strings has also been tested on the same lines. A graded series of clamped-free steel reeds is tuned according to the notes of the musical scale. The principle of excitation is that applied in the ordinary telephone earpieces, a separate electromagnet connected to the out-put transformer of the valve amplifier being provided for every different reed. In the actual experiment it was found that a note emitted by a reed is not completely deprived of the original vocal character. Also

Simultaneous photographs of the waveform of the note sung and note reproduced. Imposed vibrations are obtained by singing different vowels (आ and ई) to give the same note (upper curves). All other adjustment is kept the same. Sound emitted by the string is of the same quality (Lower curves).

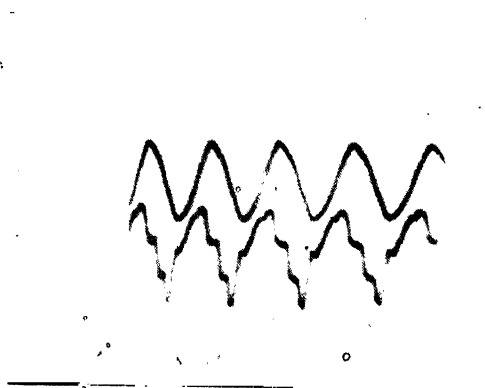


Photograph I

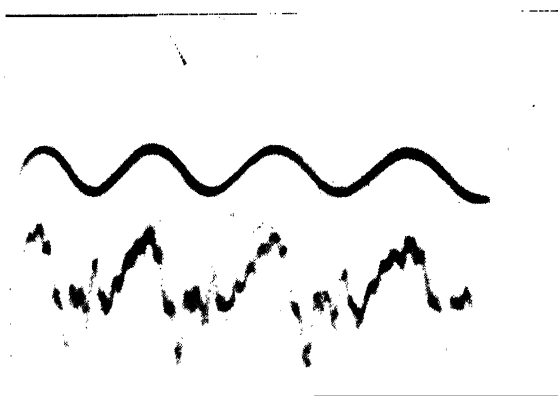


Photograph II

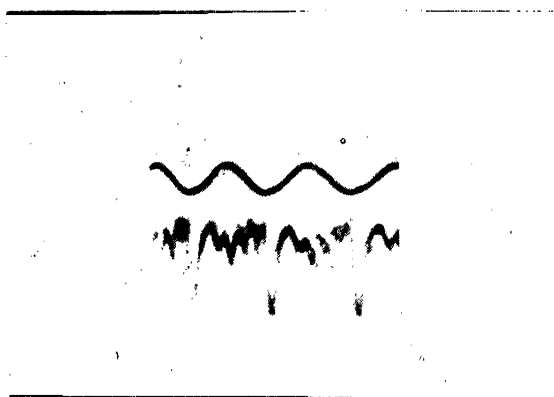
Simultaneous photographs of the waveform of the sound emitted by the wire (lower curves) for the accompanying three different adjustments. For comparison the exciting current is of the same quality (upper curves).



Photograph III



Photograph IV



Photograph V

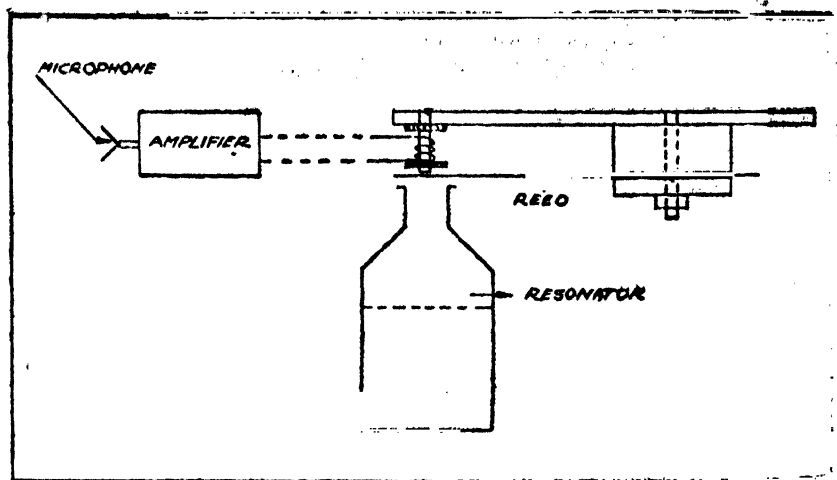


Fig. VI. Use of Reeds

the background noise produced by all other reeds not in tune is appreciably great. The vocal character of the reproduced note can be practically removed by the use of double resonators in which reeds transmit energy to the correspondingly tuned resonators. The reeds are fixed on separate blocks which are held by stands through felt packing, so that the reeds do not radiate appreciable sound. A series of air cavity resonators is so arranged that the reeds vibrate at the opening of correspondingly tuned resonators. When a note is sung there is no appreciable background noise and the resonator in tune gives a pure musical note without any vocal part. Another possible method is to fix the reed to a small diaphragm which forms one closed end of the correspondingly tuned resonator pipe.

The tuning of reeds and resonators is very tedious and because Indian music does not employ any fixed scale as such, the above method is not easily applicable. It was found very convenient to use audio-oscillator for tuning.

FURTHER POSSIBLE DEVELOPMENTS

Great developments have been made in the production of musical sounds by means of valve oscillators and loud-speakers. The older methods of production of sounds by direct mechanical means are replaced by utilising valve oscillators tuned circuits wave filters etc., with a key board, each key of which connects the appropriate oscillatory circuits to the loud-speaker. Pianoforte tones and even violin tones can also be reproduced. Various combinations also produce beautiful but hitherto unknown effects.

A sharply tuned reed with proper point of excitation can be made to vibrate only by a note of the same fundamental frequency but of any quality. A photocell circuit arranged with this can be made to operate a corresponding key. Thus a series of sharply tuned reeds and photocell circuits will operate corresponding keys, so as to provide a sort of automatic accompaniment of any desired quality. A heterodyne method (modulation of high frequency waves by sound and band pass filters) as is used in sound analysis can possibly serve the purpose of reeds. A series of tuned hot wire microphones with separate amplifiers and tuned sound radiators is also worth trying.

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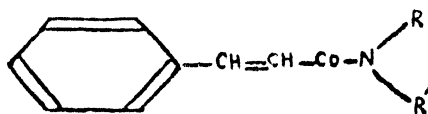
SYNTHETIC MOSQUITO LARVICIDES: PART I

By V. G. GOKHALE, N. L. PHALNIKAR* AND B. V. BHIDE

IN a previous paper (Pendse, Gokhale, Phalnikar and Bhide, J. Univ. Bom., XV, iii, 26, 1946) a number of plants were tested for their mosquito-larvicidal properties and a technique has been described for testing this property. In the present work some synthetic compounds have been described and tested for their mosquito-larvicidal property.

Among the plants studied and tested in the paper mentioned above, it was found that the extract of *Spilanthes acmella* had good larvicidal property. It was also shown that the larvicidal property of the extract was due to the presence of isobutyl amide of decadienoic acid (*Spilanthol*). Further work on similar lines (unpublished work) showed that piperides of tetrahydropiperic acid and other unsaturated acids likewise possess high mosquito larvicidal property. A review of the recent literature on insecticides also shows that amides of suitably constituted unsaturated acids have good larvicidal property, e.g., U. S. Patent No. 2, 354, 193 (C.A., 38, 6484, 1944) describes insecticides from cinnamamide and cinnamanilide of the type

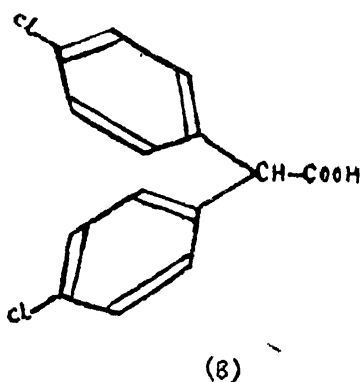
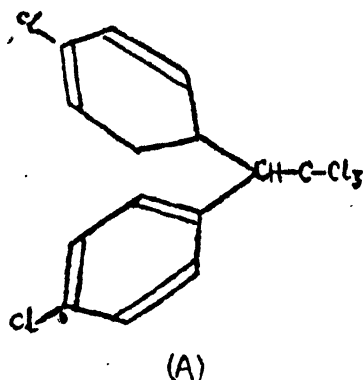
where R and R' may be alkyl or aromatic radicals. U. S. Patent No. 2, 384, 811 (C.A., 39, 5372, 1945) describes se-



condary 2-chloroallyl amides of phenyl acetic acid, crotonic acid, etc., which are claimed to possess insecticidal property. Fred Acree, Martin Jacobson and H. L. Haller, (J. Org. Chem. 10, 236, (1945) describe isolation of isobutyl amide of $\Delta^2 : 6 : 8$ decatienoic acid from the roots of *Erigeron affinis* D. C. and have shown that it possesses insecticidal property. Diallyl amide of undecylenic acid has been claimed to have insecticidal property. (U. S. Patent No. 2379223), (C. A., 39, 4170, 1945). N-substituted amides have shown considerable promise as insecticides. 2-Furan acrylamide, for example, has been found to be toxic to beet web worm, melon worm, cabbage worm and the southern army worm, (Smith, Ind. Eng. Chem., 34, 499, 1942). From this it appears that the insecticidal property depends on (i) a high degree of unsaturation in the acid group; (ii) comparatively high molecular weight of the acid generally corresponding to 10-12 carbon atoms; (iii) an amide grouping containing a substituent on the nitrogen atom containing 1 to 4 carbon atoms. It was thought, therefore, worthwhile to prepare several amides of different acids and to study their larvicidal property.

* Junior Research Fellow, National Institute of Sciences of India, Delhi, 1946.

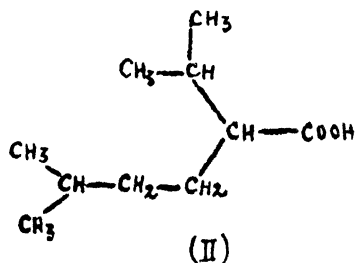
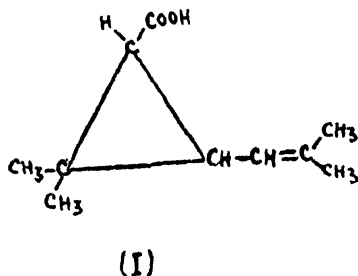
D.D.T.—the well-known insecticide—has the following structure (A).



It is also the best known mosquito larvicide. In p-p-dichloro diphenyl acetic acid (B) the main structure of D. D. T. is maintained. Several amides of this acid have been prepared and as expected were found to be good larvicides. Incidentally the amides of diphenyl acetic acid have been prepared and investigated for their larvicidal property. They have, however, very little larvicidal property. It seems, therefore, that in D. D. T. the chlorine in the para position has a predominant toxic action.

Pyrethrum extract contains pyrethrum I and Pyrethrum II as the active constituents. These are esters of crysanthemum mono carboxylic acid and crysanthemum dicarboxylic acid mono methyl ether and pyrethrolone. Crysanthemum mono carboxylic acid has the structure (I). The nearest open chain analogue of this acid (I) would be iso-propyl-iso-amyl acetic acid (II). Amides of this acid have been prepared but have been found to be liquids. However they have been found to be very active.

Incidentally a few amides of piperic acid have been prepared and have been tested for their larvicidal property.



EXPERIMENTAL

Preparation of Acids :

Diphenyl acetic acid and p-p dichlorodiphenyl acetic acid were prepared by the method described in Organic synthesis. (Org. Synthesis, Collective vol. Ed. 1944, page 224 : Org. Synthesis, 26, 21) Isopropyl isoamyl acetic acid was prepared according to the method of Nef. (Ann, 318, 159, (1901)). Piperic acid was obtained by the alkaline hydrolysis of piperine obtained from *Piper nigrum*.

Preparation of Amides :

The acids were converted into the corresponding acid chlorides by heating with thionyl chloride by the usual method. The amides were obtained by mixing the acid chlorides with an excess of the appropriate base. Amides from methyl and dimethyl amines were prepared similarly by using their solutions in benzene (dry). The following table gives the physical properties and analytical data of the amides prepared :—

TABLE I

S. No.	Name of Compound	M. P. and Crystallisation	Analysis	
			% N. (Found)	% N. (Theory)
1.	Diphenyl Acetamide	m. p. 162-163 from alcohol. (Lit. gives m. p. 161°)		
2.	N-methyl amide of Diphenyl acetic acid	m. p. 163-164 long needles from Benzene	6.1	6.2
3.	N-Dimethyl Diphenyl acetamide	m. p. 130 needles from Benzene	6.1	5.9
4.	N-Diethyl-Diphenyl acetamide	m. p. 62-63 fine white needles from dilute Methyl alcohol	5.39	5.2
5.	N-Dibutyl Diphenyl acetamide	Liquid	Not analysed	
6.	N- β -monohydroxy Ethyl Diphenyl acetamide	m. p. 122-123. white long needles from Benzene	5.7	5.5
7.	N-Di- β -hydroxyethyl Diphenyl acetamide	m. p. 108-109 long needles from alcohol dilute	4.68	4.6
8.	N-Diphenyl acetyl Piperidine	m. p. 103-104 white needles from dil. alcohol	4.8	4.5
9.	p-p-dichloro Diphenyl acetamide	m. p. 155-156, cubes, from methyl alcohol	5.0	5.0
10.	N-methyl pp'-dichloro Diphenyl acetamide	m. p. 158 clusters of needles from alcohol (dilute)	4.93	4.8
11.	N-diethyl-pp'-dichloro diphenyl acetamide	Long needles from methyl alcohol m. p. 138	4.20	4.2
12.	N-hydroxy-Ethyl pp'-dichloro Diphenyl acetamide	White needles from benzene m. p. 129-130	4.1	4.3
13.	N-pp'-dichloro Diphenylacetyl piperidine	Clusters of needles from dil. alcohol m. p. 119-120	4.15	4.0
14.	Isopropyl-Isoamyl acetamide	m. p. 110-111 found (Lit. gives 112°)		
15.	N-dimethyl-Isopropyl Isoamyl acetamide	Liquid	Not analysed	

S. No.	Name of Compound	M. P. and Crystallisation	Analysis	
			% N. (Found)	% N. (Theory)
16.	N-diethyl-Isopropyl Isoamyl-acetamide	Liquid	Not analysed	
17.	N-methyl-piperic acid-amide	m. p. 186 from benzene short needles	6.2	6.1
18.	N-Dimethyl piperic acid-amide	m. p. 160-161 from Benzene	5.8	5.7

Following the technique described by Pendse, Gokhale et. al. (loc. cit.) larvicidal property of the amides was determined and the results are given in following Table II:—

TABLE II

S. No.	Name of Compound	Concentration and Time of Death		
		1 : 10,000	1 : 20,000	1 : 40,000
1.	Diphenyl Acetamide	All living 24 hours	All living 24 hours	All living 24 hours
2.	N-methyl amide of Diphenyl acetic acid	All living in 24 hrs.	All living in 24 hrs.	All living in 24 hrs.
3.	N-Dimethyl Diphenyl acetamide	All living 24 hrs.	All living 24 hrs.	All living 24 hrs.
4.	N-Diethyl Diphenyl acetamide	All living 24 hrs.	—do— 24 hrs.	—do— 24 hrs.
5.	N-Dibutyl Diphenyl acetamide	Dead after 24 hrs.	All living 24 hrs.	All living 24 hrs.
6.	N- β -monohydroxy Ethyl Diphenyl acetamide	All living 24 hrs.	All living 24 hrs.	All living 24 hrs.
7.	N-Di (β hydroxy Ethyl) Diphenyl acetamide	All dead 12 hrs.	All living 24 hrs.	All living 24 hrs.
8.	N-Diphenyl Acetyl Piperidine	Only 25% dead in 24 hrs.	Living 24 hrs.	Living 24 hrs.
9.	PP'-dichloro Diphenyl acetamide	All dead 8 hrs.	dead 75% 24 hrs.	Living 24 hrs.
10.	N-methyl pp'-dichloro diphenyl acetamide	All dead 6 hrs.	Dead 24 hrs.	Living 24 hrs.
11.	N-diethyl pp'-dichloro diphenyl acetamide	All dead 6 hrs.	All dead 24 hrs.	All dead 24 hrs.
12.	N- β -hydroxy Ethyl pp'-dichloro diphenyl acetamide	All dead 6 hrs.	All dead 24 hrs.	All dead 24 hrs.

S. No.	Name of Compound	Concentration and Time of Death		
		1 : 10,000	1 : 20,000	1 : 40,000
13.	N-pp'-dichloro Diphenyl-acetyl piperidine	All dead 6 hrs.	All dead 24 hrs.	All dead 24 hrs.
14.	Isopropyl-Isoamyl acetamide	All dead in 10 minutes	All dead 10 minutes	All dead 15 minutes
15.	N-Dimethyl-Isopropyl Isoamyl-acetamide	All dead in 10 minutes even pupæ dead 9 hrs.	50% dead in 10 minutes even pupæ after 24 hrs.	50% dead in 10 minutes even pupæ after 24 hrs.
16.	N-diethyl Isopropyl Isoamyl acetamide	All dead 24 hrs.	50% dead 24 hrs.	50% dead 24 hrs.
17.	N-methyl piperic acid amide	All dead 9 hrs.	Living 24 hrs.	Living 24 hrs.
18.	N-Dimethyl piperic acid amide	All dead $\frac{1}{2}$ hour	50% dead 24 hrs.	Living 24 hrs.

CONCLUSIONS

1. It will be seen from the above table that the various amides of diphenylacetic acid have no larvicidal action although a slight action is shown by the amide from dibutyl amine, diethanol amine and piperidine.

2. The amides of the pp'-dichloro diphenyl acetic acid, on the other hand, showed considerable activity. Amides from diethyl amine, ethanol amine and piperidine were quite active.

3. Amides of isopropyl isoamyl acetic acid were also active. The simple amide is the most active and quick in action. Its insecticidal properties deserve to be studied in detail further. It has been found that unsaturation enhances insecticidal power. In Isopropyl isoamyl acetic acid there is no unsaturation but it is a branched chain acid. Amides of acids having several branches, therefore, are worth studying.

4. Amides of piperic acid are also active but the results are not strictly comparable because suspensions were unstable and amides separated within a few minutes. It is necessary to repeat the experiments with more stabilized solutions.

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[Received: July 24, 1947]

SYNTHETICAL ANTHELMINTICS

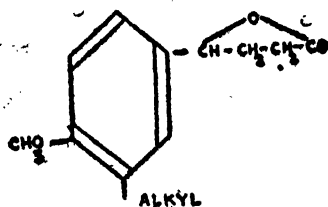
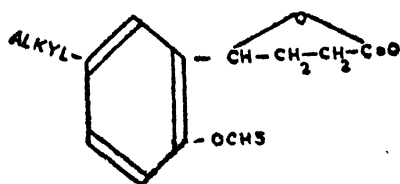
Part XIV. γ -2-methoxy-5-alkyl-phenyl butyrolactones

Part XV. γ -4-methoxy-3-alkyl-phenyl butyrolactones

BY K. R. IRANI, N. L. PHALNIKAR AND K. S. NARGUND

IN the para-n-alkyl phenol series it has been found that the bactericidal activity and the ascaricidal properties increase up to a certain limit with increase in the length of the alkyl group, further increase in the alkyl group leading to rapid decrease in these properties. (Coulthard Marshall and Pyman J. C. S. 1930, 280. Lamson and co-workers J. Pharmacol, 53, 218, 1935). Lamson and co-workers also found that the ascaricidal properties were the same in the para-alkyl phenols and the ortho-alkyl phenols although ortho-alkyl phenols had less irritant action than the para-alkyl phenols. Nargund and co-workers (J. Ind. Med. Asso., 14, 69, 1945) prepared and tested for anthelmintic properties a number of p-methoxy-phenyl alkyl-butyrolactones with alkyl group on α - and γ -carbon atoms of the butyrolactone group and found that the toxicity of the lactones increased with the increase of the alkyl group up to three carbon atoms, further increase leading to decrease in toxicity. They also found that the lactones having the alkyl group on the α -carbon were less toxic than those having the alkyl group on the γ -carbon. The present work is intended to study the effect of alkyl substitution in the benzene nucleus of the methoxy phenyl-butyrolactones on their anthelmintic properties.

The following types of lactones are described.



2-methoxy-5-alkyl phenyl butyrolactones :—p-alkyl anisoles were prepared by the Clemmensen's reduction of p-acyl anisoles which were prepared either by the Friedel and Crafts reaction of an acyl chloride with anisole (Paranjape, Phalnikar and Nargund, J. Bom. Univ. 11, iii, 120, 1942) or by the action of the Grignard reagent of an alkyl bromide on anisic amide. P-alkyl anisoles were condensed with succinic anhydride by Friedel and Crafts reaction using nitrobenzene as solvent. The constitutions of the resulting keto acids were proved by oxidation and demethylation to the corresponding alkyl salicylic acids, authentic specimens of which were prepared for the sake of comparison by the method of Cox (J. A. C. S. 52, 352, 1930). The hitherto unknown 5-alkyl sali-

cylic acids ($C_6H_3COOH OH$ Alkyl 1-2-5-), viz., n-amyl and n-heptyl salicylic acids have been prepared by the same method. The keto acids were reduced and lactonised by the procedure of Trivedi and Nargund. (J. Bom. Univ. 10, iii, 99, 1941).

4-Methoxy-3-alkyl phenyl butyrolactones:—These were prepared from ortho alkyl anisoles by the same reactions as in the case of para series. o-alkyl anisoles were prepared by Clemmensen's reduction and methylation of ortho acyl phenols which were obtained either by Nencki's reaction or Frie's migration of phenol esters. Good yields of o-acyl anisoles were obtained by the action of the Grignard Reagent of alkyl bromides on o-methoxy benzamide but the Clemmensen's reduction of o-acyl anisoles was difficult. O-cresol methyl ether has been condensed with succinic anhydride by Rosenmond and Schapiro (Arch. Pharm. 272, 313, 1934). They showed that the compound obtained was β -4-methoxy-3-toluoyl propionic acid indicating that the condensation had taken place in para position to the methoxy group. The constitutions of the acids obtained by the condensation of succinic anhydride with o-alkyl anisoles are by analogy assumed to be β -4-methoxy-3-alkyl benzoyl propionic acids. These have been reduced and lactonised.

The lactones described in this paper have been tested on fish and earthworms and the results will be reported in due course.

EXPERIMENTAL

General procedure for the condensation of succinic anhydride with alkyl anisoles:—Succinic anhydride (0.1 mol) alkyl anisole (0.1 mol), nitrobenzene (75 gms.) and anhydrous aluminum chloride (28 gms.) were mixed together in cold and kept at room temperature for four hours. It was then decomposed with ice and hydrochloric acid and steam distilled to remove nitrobenzene. The substance thus obtained was dissolved in dilute sodium carbonate solution, filtered and the filtrate acidified. The yields of the keto acids obtained by the above procedure are recorded in the following table:—

Alkyl anisole used	Keto acid obtained	Yield per cen
p-ethyl anisole	β -2-methoxy-5-ethyl benzoyl propionic acid	..
p-n propyl anisole	β -2-methoxy-5-n propyl benzoyl propionic acid	.. 70
p-n butyl anisole	β -2-methoxy-5-n butyl benzoyl propionic acid	.. 55
p-n amyl anisole	β -2-methoxy-5-n amyl benzoyl propionic acid	.. 55
p-n hexyl anisole	β -2-methoxy-5-n hexyl benzoyl propionic acid	.. 84
p-n heptyl anisole	β -2-methoxy-5-n heptyl benzoyl propionic acid	.. 80
-o ethyl anisole	β -4-methoxy-3-ethyl benzoyl propionic acid	.. 85
o-n butyl anisole	β -4-methoxy-3-n butyl benzoyl propionic acid	.. 80
o-n amyl anisole	β -4-methoxy-3-n amyl benzoyl propionic acid	.. 78
o-n hexyl anisole	β -4-methoxy-3-n hexyl benzoyl propionic acid	.. 65

The properties of the above compounds and their derivatives are described in tabular form below.

Name of Compound and Formulae	Properties	Analysis	
		Found	Required
2-methoxy-5-ethyl benzoyl propionic acid $C_{13}H_{16}O_4$	sol in common solvents and hot water thin wooly needles from water or alcohol m. p. 101-102. On oxidation it gave ethyl salicylic acid m. p. 120°	C, 65.9; H, 6.9 eq. wt. 238.8	C, 66.1; H, 6.8 eq. wt. 236
2-methoxy-5-ethyl phenyl butyrolactone $C_{13}H_{16}O_3$	obtained by reduction and lactonisation of the above acid was a thick colourless liquid b. p. 280° at 36 mm.	C, 70.7; H, 7.4 eq. wt. by back titration 213.7	C, 70.9; H, 7.3 eq. wt. 220
2-methoxy-5-n-propyl benzoyl propionic acid $C_{14}H_{18}O_4$	wooly needles from petrol or hot water fan shaped crystals from alcohol or benzene m. p. 104-105. On oxidation it gave propyl salicylic acid m. p. 99°	C, 67.0; H, 7.2 eq. wt. 230	C, 67.2; H, 7.2 eq. wt. 230
Ethyl 2-methoxy-5-n-propyl benzoyl propionate $C_{16}H_{22}O_4$	prepared by Fischer Speier method from the above acid crystallised in fan shaped needles from benzene m. p. 49°	C, 69.0; H, 8.0	C, 69.1; H, 7.9
2-methoxy-5-n-propyl phenyl butyrolactone $C_{14}H_{18}O_3$	a colourless thick liquid b. p. 215-220° at 50 mm.	C, 71.6; H, 7.7 eq. wt. 232	C, 71.8; H, 7.7 eq. wt. 234
2-methoxy-5-n-butyl benzoyl propionic acid $C_{15}H_{20}O_4$	plates or leaves from dilute alcohol m. p. 112-113 oxidation gave butyl salicylic acid m. p. 84-86°	C, 68.3; H, 7.4 eq. wt. 259	C, 68.2; H, 7.6 eq. wt. 264
2-methoxy-5-n-butyl phenyl butyrolactone $C_{15}H_{20}O_3$	thick liquid b. p. 220° at 60 mm.	C, 72.4; H, 8.3 eq. wt. 242.5	C, 72.6; H, 8.1 eq. wt. 248
2-methoxy-5-n-amyl benzoyl propionic acid $C_{16}H_{22}O_4$	needles from petroleum ether m. p. 84-85. On oxidation it gave n amyl salicylic acid m. p. 89° described below	C, 68.8; H, 7.9 eq. wt. 278	C, 69.1; H, 7.9 eq. wt. 278
Methyl valeryl salicylate $C_{13}H_{16}O_4$	prepared by the action of valeryl chloride on methyl salicylate had b. p. 228° at 20 mm.	C, 65.9; H, 6.8	C, 66.1; H, 6.8
Valeryl salicylic acid $C_{12}H_{14}O_4$	obtained by the hydrolysis of the above crystals from petrol m. p. 143°	C, 64.6; H, 6.3 eq. wt. 221	C, 64.9; H, 6.3 eq. wt. 222
n-amyl salicylic acid $C_{12}H_{16}O_3$	by the Clemmensen reduction of the above	C, 69.0; H, 7.7 eq. wt. 208	C, 69.2; H, 7.7 eq. wt. 208
2-methoxy-5-n amyl phenyl butyrolactone $C_{16}H_{22}O_3$	thick liquid b. p. 238-240° at 15 mm. $N_D^{26}=1.5135$ $D_4^{26}=1.065$	C, 73.1; H, 8.5 eq. wt. 259	C, 73.7; H, 8.4 eq. wt. 262

Name of Compound and Formulae	Properties	Analysis	
		Found	Required
2-methoxy-5-n hexyl benzoyl propionic acid $C_{17}H_{24}O_4$	fine needles from petrol wooly needles from hot water or dilute alcohol m. p. 75-76. On oxidation it gave hexyl salicylic acid m. p. 83°	C, 69.6; H, 8.2 eq. wt. 292	C, 69.9; H, 8.2 eq. wt. 292
Methyl 2-methoxy-5-n hexyl benzoyl propionate $C_{18}H_{26}O_4$	From the above acid by esterification, liquid b. p. 228-230° at 13 mm. $D_4^{26.6}=1.080$ $N_D^{26.6}=1.5129$	C, 70.4; H, 8.6 "	C, 70.6; H, 8.5 "
Ethyl 2-methoxy-5-n hexyl benzoyl propionate $C_{19}H_{28}O_4$	b. p. 225 at 12 mm.	C, 71.1; H, 8.8	C, 71.3; H, 8.8
2-methoxy-5-n hexyl phenyl butyrolactone $C_{17}H_{24}O_3$	liquid b. p. 238-240° at 22 mm. $D_4^{27}=1.056$ $N_D^{27}=1.5130$	C, 73.7; H, 8.8 eq. wt. 274	C, 73.9; H, 8.7 eq. wt. 276
2-methoxy-5-n heptyl benzoyl propionic acid $C_{18}H_{26}O_4$	thin wooly needles from hot water or dilute alcohol or petrol. m.p. 63-64°. On oxidation it gave heptyl salicylic acid m. p. 87° described below	C, 70.4; H, 8.6 eq. wt. 305	C, 70.6; H, 8.5 eq. wt. 306
Methyl n heptyl salicylate $C_{15}H_{20}O_4$	from methyl salicylate and heptyl chloride, liquid b. p. 230° at 50 mm.	C, 68.0; H, 7.6	C, 68.2; H, 7.6
n heptyl salicylic acid $C_{14}H_{18}O_4$	By the hydrolysis of the above by alkali, crystals from benzene petrol mixture m. p. 106°	C, 67.1; H, 7.3 eq. wt. 251	C, 67.2; H, 7.2 eq. wt. 250
n heptyl salicylic acid $C_{14}H_{20}O_3$	By the Clemmensen reduction of the above, needles from petrol m. p. 87°	C, 70.9; H, 8.4 eq. wt. 235	C, 71.2; H, 8.5 eq. wt. 236
Ethyl 2-methoxy-5-n heptyl benzoyl propionate $C_{20}H_{28}O_4$	By esterification from the corresponding acid, needles from petrol m. p. 39-40°	C, 71.8; H, 9.0	C, 71.9; H, 9.0
2-methoxy-5-n heptyl phenyl butyrolactone $C_{18}H_{26}O_3$	liquid b. p. 235-240° at 10 mm. $D_4^{30}=1.036$ $N_D^{30}=1.5072$	C, 74.3; H, 8.9 eq. wt. 287	C, 74.5; H, 8.7 eq. wt. 290

We thank Professor B. V. Bhide, Head of the Chemistry Department, for his keen interest and encouragement.

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Part. XVI. γ -2-4-dimethoxy-5-alkyl-phenyl butyrolactones

By K. R. IRANI, N. L. PHALNIKAR AND K. S. NARGUND

THE effect of introducing alkyl groups into the resorcinol molecule on the bactericidal action has been found to increase with the increase of the length of the alkyl group upto hexyl after which there is a rapid falling off in bactericidal activity. (Johnson and Lane J. A. C. S. 43, 348, 1921) Hexyl resorcinol has been employed as a urinary antiseptic and also as an anthelmintic. With a view to see the effect of an additional butyrolactone group attached to an alkyl resorcinol the compounds named in the title of this paper have been prepared as a necessary preliminary step.

Acyl resorcinols required for this work were prepared by the method of Dohme, Cox and Miller (J. A. C. S. 48, 1691, 1926). They were then reduced by Clemmensen's method to alkyl resorcinols which were then methylated by dimethyl sulphate and alkali to obtain 1-3-dimethoxy-4-alkyl benzenes. These were condensed with succinic anhydride by Friedel and Craft's reaction as usual. The acid obtained by the condensation of ethyl resorcinol dimethyl ether with succinic anhydride was shown to be β -2-4-dimethoxy-5-ethyl benzoyl propionic acid as it gave, on oxidation either by alkaline potassium permanganate or by sodium hypobromite 2-4-dimethoxy-5-ethyl benzoic acid of Desai and Hamid (Proc. Ind. Accad. Sci., 64, 287, 1937). The constitutions of the other acids obtained similarly were assumed by analogy to be β -2-4-dimethoxy-5-alkyl benzoyl propionic acids. These were reduced and lactonised as usual to obtain γ -2-4-dimethoxy-5-alkyl phenyl butyrolactones.

EXPERIMENTAL

General procedure used to methylate alkyl resorcinols :—In a three necked flask fitted with a reflux condenser, an efficient stirrer and a separating funnel was placed a solution of alkyl resorcinol (0.1 mol) in sodium hydroxide (0.2 mol) in 80 cc of water. Dimethyl sulphate (0.4 mol) was added with stirring in small lots. The temperature was not allowed to go beyond 40°. More alkali was added from time to time to keep it alkaline. After stirring for two hours at room temperature it was then refluxed over a free flame for four hours with frequent addition of alkali. It was then cooled and extracted with ether twice. The ether layer was washed with water and dried over anhydrous magnesium sulphate and the product recovered after removal of ether was purified by distillation. The compounds are described in the following table along with their condensation products with succinic anhydride and their derivatives.

Name of Compound	Properties	Analysis	
		Found	Required for
1-3-dimethoxy-4-ethyl benzene $C_{10}H_{14}O_2$	liquid b.p. 229-230 at 710 mm. $N_D^{21} = 1.5109$ $D_4^{21} = 1.028$	C, 72.2 H, 8.5	C, 72.3 H, 8.4
β -2-4-dimethoxy-5-ethyl benzoyl propionic acid $C_{14}H_{18}O_5$	Obtained by the condensation of the above with succinic anhydride in 70 per cent yield m.p. 141-142. soluble in all common solvents except petrol. On oxidation it gave 2-4-dimethoxy-5-ethyl benzoic acid m.p. 125	C, 63.1 H, 6.8 eq. wt. 265	C, 63.2 H, 6.8 eq. wt. 266

Name of Compound	Properties	Analysis	
		Found	Required for
γ -2,4-dimethoxy-5-ethyl phenyl butyrolactone $C_{14}H_{18}O_4$	colourless liquid b.p. 185-186° at 5 mm.	C, 67.3 H, 7.4 eq. wt. 248	C, 67.2 H, 7.2 eq. wt. 250
1,3-dimethoxy-4-n propyl benzene $C_{11}H_{16}O_2$	liquid b.p. 250-251 at 710 mm. $N_D^{31}=1.5108$ $D_4^{31}=1.019$	C, 73.2 H, 9.0	C, 73.3 H, 8.8
β -2,4-dimethoxy-5-n propyl benzoyl propionic acid $C_{15}H_{20}O_5$	yield 55 per cent crystallised from benzene or water m.p. 141-142	C, 64.0 H, 7.3 eq. wt. 280	C, 64.3 H, 7.1 eq. wt. 280
Ethyl β -2,4-dimethoxy-5-n propyl benzoyl propionate $C_{17}H_{24}O_5$	obtained by esterification of the above. liquid b.p. 254 at 28 mm. $N_D^{31}=1.5121$ $D_4^{31}=1.217$	C, 66.1 H, 7.9	C, 66.2 H, 7.8
γ -2,4-dimethoxy-5-n propyl phenyl butyrolactone $C_{15}H_{20}O_4$	liquid b.p. 200-203° at 3 mm.	C, 68.1 H, 7.5	C, 68.2 H, 7.6
1,3-dimethoxy-4-n butyl benzene $C_{12}H_{18}O_2$	liquid b.p. 264° at 710 mm. $N_D^{31}=1.5039$ $D_4^{31}=1.006$	C, 74.1 H, 9.4	C, 74.2 H, 9.3
β -2,4-dimethoxy-5-n butyl benzoyl propionic acid $C_{16}H_{22}O_5$	yield 60 per cent. crystallised from benzene or alcohol m.p. 141-142	C, 65.2 H, 7.4 eq. wt. 295	C, 65.3 H, 7.5 eq. wt. 294
Ethyl β -2,4-dimethoxy-5-n butyl benzoyl propionate $C_{18}H_{26}O_5$	b.p. 223-225° at 10 mm. solidified on cooling m.p. 45-47. It crystallised in fan shaped crystals from petrol	C, 67.0 H, 8.2	C, 67.1 H, 8.1
γ -2,4-dimethoxy-5-n butyl phenyl butyrolactone $C_{16}H_{22}O_4$	liquid b.p. 210-211 at 4 mm.	C, 68.8 H, 8.1	C, 69.1 H, 7.9
1,3-dimethoxy-4-n hexyl benzene $C_{14}H_{22}O_2$	liquid b.p. 300° at 710 mm. $N_D^{25}=1.5018$ $D_4^{25}=0.9858$	C, 75.5 H, 9.9	C, 75.7 H, 8.9
β -2,4-dimethoxy-5-n hexyl benzoyl propionic acid $C_{18}H_{26}O_5$	yield 56 per cent. crystallised from alcohol m.p. 141	C, 66.9 H, 8.2 eq. wt. 322	C, 67.1 H, 8.1 eq. wt. 322
Ethyl β -2,4-dimethoxy-5-n hexyl benzoyl propionate $C_{20}H_{30}O_5$	clusters of needles from dilute alcohol m.p. 54-55	C, 68.4 H, 8.6	C, 68.6 H, 8.6
γ -2,4-dimethoxy-5-n hexyl phenyl butyrolactone $C_{18}H_{26}O_4$	thick liquid b.p. 225-227° at 3 mm.	C, 70.5 H, 8.4	C, 70.6 H, 8.5

One peculiarity of the keto acids obtained from the condensation of alkyl resorcinol dimethyl ethers with succinic anhydride is that all of them have the same m.p. viz. 141°. The mixed m.p. of any two of them, however, was low viz. 120-124°.

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CHALKONES:

Condensation of 2 : 4-Dimethoxyacetophenone, 2 : 4-Dimethoxy-5-Bromo-Acetophenone, 2-Hydroxy-4-Benzyloxyacetophenone and 2-Hydroxy-4-Benzyloxy-5-Bromoacetophenone with 2-Methoxybenzaldehyde and 2-Methoxy-4-Bromo-Benzaldehyde, Bromination of the Chalkones and Study of the Reactivity of the Bromo Derivatives

BY H. P. VANDREWALA AND G. V. JADHAV

THE chalkones I to IV and VI to IX were prepared by condensing requisite ketones and aldehydes in presence of alkali according to the method of Sorge¹. When (I) was brominated in carbon tetrachloride solution by using the reactants in the proportion 1 : 1, only a monobromo compound with bromine in the acetophenone nucleus was obtained whose constitution was confirmed by synthesis. This showed that that nucleus was more reactive than even the double bond in the molecule, but as compared with resacetophenone derivative it was less reactive, as the latter under similar conditions gave a disubstitution product. This was due to the methylation of the hydroxyl groups. When brominated with excess of bromine in chloroform solution it gave a tetrabromo derivative (V) with two bromine atoms added at the double bond and two in the two nuclei (one being in each). The constitution of (V) was proved by brominating the ketone (III) as well as by the interaction of potassium iodide on it.

With potassium iodide ketone (V) gave the styryl ketone (III) with the liberation of iodine which showed that both the bromine atoms were labile (cf. Dodwadmath and Wheeler²; Barne and Payton³; Nadkarni, Warrior and Wheeler⁴).

With pyridine ketone (V) gave α -bromo-styryl ketone (X) thus showing that β -bromine atom was more labile (cf. Nadkarni, Warrior and Wheeler⁴; Bhagwat and Wheeler⁵; Rao and Wheeler⁶).

With sodium alkoxide, ketone (V) gave β -alkoxy-styryl ketones (XI) and (XII) (cf. Köhler and Addinall⁷; Nadkarni, Warrior and Wheeler⁴; Bhagwat and Wheeler⁵; Jadhav and Vandrewala⁸), which again pointed out to the more labile nature of β -bromine atom.

EXPERIMENTAL

2 : 4-Dimethoxy-phenyl β -2'-methoxy-styryl ketone (I):—2 : 4-Dimethoxyacetophenone (5 g.), o-methoxybenzaldehyde (4 g.), ethyl alcohol (50 cc) and caustic potash (10 g. in 15 cc water) were mixed in a tightly corked flask and left at room temperature for about 24 hours. The mixture was then diluted with water and acidified with hydrochloric acid. The product finally crystallised from acetic acid in shining yellow plates, m.p. 106-7°. Found : C, 72.2; H, 6.2 $C_{18}H_{18}O_4$ requires C, 72.5; H, 6.04 per cent.

Ketone (V) (2 g.), potassium iodide (0.7 g.) and acetone (150 cc) were mixed and boiled under reflux for about 2 hours. The solid obtained after the removal of the solvent was washed with sodium thiosulphate and crystallised from a mixture of acetic acid and alcohol in yellow needles, m.p. 194-5°. Found; Br, 35.2; $C_{11}H_{11}O_4Br_2$ requires Br, 35.1 per cent. It is identified as 2:4-dimethoxy-5-bromo-phenyl β -2'-methoxy-5'-bromocycryl-ketone (III), as it showed no lowering in melting point when mixed with it.

ACTION OF PYRIDINE

The ketone (V) (3 g.) was boiled with pyridine (15 cc) for about 5 minutes and diluted with alcohol (150 cc). The solid obtained was washed with hydrochloric acid and finally crystallised from acetic acid in pale yellow plates, m.p. 173-4°. Found: Br, 46.1; $C_{18}H_{15}O_4Br_3$ requires Br, 44.9 per cent. This should be 2:4-dimethoxy-5-bromophenyl- α -bromo- β -2'-methoxy-5'-bromo-styryl ketone (X).

ACTION OF SODIUM ALKOXIDE

Ketone (V) (10 g.) was boiled with metallic sodium, benzene (100 cc) and ethyl alcohol (150 cc) for about 3½ hours and the solid obtained on cooling the reaction mixture crystallised from acetic acid in yellow needles, m.p. 189-90°. Found: Br, 32.5; $C_{20}H_{20}O_5Br_2$ requires Br, 32 per cent. It should be 2:4-dimethoxy-5-bromo-phenyl β -ethoxy- β -2'-methoxy-5'-bromo-styryl ketone (XI).

* Under similar conditions sodium methoxide gave 2:4-dimethoxy-5-bromophenyl β -methoxy- β -2'-methoxy-5'-bromo-styryl ketone (XII), m.p. 192-3°. Found: Br, 33.3; $C_{19}H_{18}O_5Br_2$ requires Br, 32.9 per cent.

One of the authors (H. P. V.) has to thank late Dr. D. R. Nadkarni.

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NITRATION OF METHYL-7-METHOXY-4-METHYL-COUMARIN-6-CARBOXYLATE

By A. R. NAIK AND G. V. JADHAV

THE nitration of methyl-7-methoxy-4-methyl-coumarin-6-carboxylate was taken up with a view to study the course of the reaction, for it is known that methyl ethers of coumarin behave differently towards nitration as compared with the hydroxy compounds (cf. Pechmann and Obermiller, Ber., 1901, 34, 666; Dey and Kutti, Proc. Nat. Inst. Sc., 1940, 6, 641).

As in the case of the hydroxy compounds here also the course of the reaction depended on the medium of the reaction. In acetic acid medium it gave a mono nitro compound without the carbmethoxy group. Hence it must be 7-methoxy-4-methyl-6-nitro-coumarin, which was confirmed by mixed melting point. Nitration in sulphuric acid medium gave a dinitro compound whose constitution was proved by demethylating it, when the hydroxy compound was found to be identical with methyl-7-hydroxy-4-methyl-3 : 8-dinitro-coumarin-6-carboxylate.

EXPERIMENTAL

7-Methoxy-4-methyl-6-nitrocoumarin (II) :—Fuming nitric acid (20 cc, 1.5 d) was gradually added to methyl-7-methoxy-4-methyl-coumarin-6-carboxylate (I) suspended in acetic acid (30 cc) and the reaction mixture was kept at room temperature for 3 days. The reaction mixture was then diluted with water and the solid obtained crystallised from acetic acid in white needles, m.p. 282°.

Found : N, 5.9; $C_{11}H_9O_5N$ requires N, 5.95 per cent.

Methyl-7-methoxy-4-methyl-3 : 8-dinitrocoumarin-6-carboxylate (III) :—A mixture of nitric acid (10 cc, 1.42 d) and sulphuric acid (10 cc) was added drop by drop to the solution of the ester (I) (5 g.) dissolved in sulphuric acid (50 cc) cooled by ice. After the addition was over the reaction mixture was left at room temperature for about half an hour and then poured over crushed ice. The solid crystallised from acetic acid in straw coloured cubes, melting at 232-33°. It was sparingly soluble in methyl alcohol, ethyl alcohol and acetic acid. Found : N, 8.2; $C_{13}H_{11}O_9N_2$ requires N, 8.3 per cent.

Methyl-7-hydroxy-4-methyl-3 : 8-dinitrocoumarin-6-carboxylate (IV) : Hydrobromic acid solution in acetic acid (30 per cent.) (10 cc) was added to the ester (III) dissolved in acetic acid (10 cc) and heated under reflux at 140-50° for about 4 hours. It was then poured into water and the solid crystallised from crushed ice in yellow cubes, m.p. 146-7°. It showed no lowering in melting point with authentic specimen. (Naik and Jadhav, under publication).

7-Methoxy-4-methyl-3 : 8-dinitrocoumarin-6-carboxylic acid (V) :—The ester (III) (2 g.) was dissolved in just sufficient acetic acid and sulphuric acid (8 cc) added and boiled for 3 hours. The solid obtained on pouring the solution over crushed ice crystallised from alcohol, m.p. 234-5° (decomp.). Found :—N, 8.8; $C_{12}H_8O_9N_2$ requires N, 8.6 per cent.

This acid was esterified to (III) by boiling it with methyl alcohol in presence of sulphuric acid for 16 hours.

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CHEMICAL INVESTIGATION OF THE FRUITS OF PIPER LONGUM (LINN)

(N. O. Piperaceæ)

BY V. G. GOKHALE, N. L. PHALNIKAR* AND B. V. BHIDE

AMONG the various plant larvicides studied in this laboratory the extract of *Spilanthes Acmella* was found to be the most efficient. The activity of the extract of this plant was shown to be due to spilanthol which produces a characteristic tingling sensation when put on the tongue. (Gokhale, Pendse, Phalnikar and Bhide, J. Univ. Bom., 15, iii, 26, 1946). Ether extract of piper longum also produces a similar tingling sensation with a burning taste. The burning taste is undoubtedly due to the piperine content of the fruits. Piperine itself, however, was not found to have any larvicidal property while the ether extract of piper longum was more efficient. Therefore the ether extract must contain a substance or substances other than piperine and having good larvicidal property. Hence the chemical investigation of the fruits of piper longum was undertaken.

Piper Longum is a shrub belonging to the natural order Piperaceae. It is found in all hotter provinces of India, Ceylon and Malaya peninsula. The plant and its fruits are widely used in indigenous medicine. The root is pungent, anthelmintic and carminative. It improves the appetite.

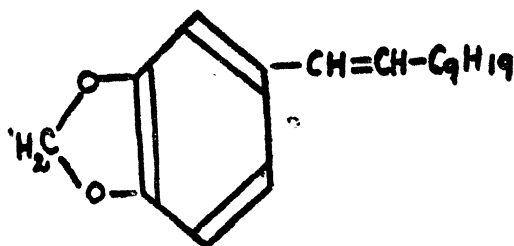
The chemical investigation of this plant has been carried out by Bauer and Hilger (Zentr. I, 1214, (1896) ; Wangerin (Pharm. Ztg., 48, 454) ; Stenhouse (Pharm. J. (I), 14, 363 ; Ann. 95, 106) ; Herlant (Pharm. J., (3), 25, 643) and Peinemenn (Arch. Pharm. 234, 245, 251). Apart from the isolation of piperine, however, a thorough chemical investigation of the various constituents has not been carried out.

Various varieties of piper longum are sold in the market and the present investigation refers to one variety which is commonly known as Pimpli in the local market. It was identified as fruits of *Piper longum* (N. O. Piperaceæ) by the Economic Botanist to the Government of Bombay.

The fruits were extracted with various solvents. The nature of the extracts is given in the experimental. A detailed investigation was made of the ether extract only. The ether extract contained a volatile oil which was removed by steam distillation. The residue on treatment with petroleum ether gave crystals which were identified as piperine. The petroleum ether soluble fraction was fractionally distilled and each fraction was separated into acidic and neutral portion. In the acidic fraction palmitic acid and tetrahydropiperic acid were identified.

* Junior Research Fellow, National Institute of Sciences of India, Delhi, 1946.

From the neutral portion a substance (E) mp. 38° , having the composition $C_{18}H_{26}O_2$ was isolated which on oxidation gave piperonylic acid. Hence its structure appears to be undecylenyl 3:4 methylene dioxy benzene (Fig. E) but the exact nature of the side chain is uncertain as compound (I), the synthesis of which is given below is not identical with it.



[E]

Fig. E

Attempts were made to synthesise (E) on the following lines :

Methylene dioxy benzene was condensed with undecoyl chloride in the presence of anhydrous aluminium chloride. The reaction mixture on working up as usual gave a product soluble in sodium hydroxide and giving colouration with ferric chloride. Evidently the dihydroxy acyl benzene seems to have been formed. However no pure product could be isolated.

The synthesis was then attempted in another way. A grignard reagent from n-decyl iodide was allowed to react with piperonal. The resulting alcohol on dehydration was expected to give the desired product. A product similar in properties to the substance (E) melting at $35-36^{\circ}$ was obtained but the mixed melting point was lowered by five degrees on mixing the synthetic substance (I) with the above natural product (E). This indicates that the side chain in (E) is probably a branched chain. However, it may be noted that the anilide of the acid obtained on oxidation of (E) melted at 67° , while the anilide of n-decoic acid melts at 68° .

The ether extract of piper longum has been also analysed in an alternative method as described in the experimental.

By this method piperidine was identified in the extract as piperidine picrate. Tetrahydropiperic acid was also identified. Liquid acids obtained by this method, however, could not be identified as they polymerised very readily.

The ether extract of Piper longum, therefore, contains the following substances :—(1) a volatile oil, (2) piperine, (3) 3:4 methylene dioxy undecylenyl benzene, (4) piperidide of tetrahydropiperic acid and (5) probably piperidides of unsaturated and easily polymerisable acids.

EXPERIMENTAL

ASH:—The ash, which was white, was analysed qualitatively and showed the presence of Fe, Mg., K, PO_4 , SO_4 and NO_3 radicals. The amount of PO_4 was considerable while potassium was present only in traces.

Extraction with different solvents :—

75 gms of the fruits of piper longum, roughly powdered, were extracted in a soxhlet successively with different solvents. The following table gives the percentage of extracts and their nature.

TABLE No. 1

Solvent	Percentage Extracted	Nature of the Extract
Petroleum Ether	2.8	Gummy viscous mass causing a tingling sensation. Gives tests for alkaloids
Ether Sulphuric	0.84	
Chloroform	0.72	
Alcohol	0.68	
Water	0.64	

Ether extract :—

Since the main interest in the work was in the pungent principle and as ether (sulphuric) was found to extract the pungent principle effectively from the fruits, 5 Kgs of the powdered fruits were extracted with ether by cold percolation till all the pungent material was removed. The combined ether extracts were dried and ether removed. About 250 gms. of a dark viscous residue were left. This was subjected to steam distillation when 12.5 gms. of a fragrant volatile oil (A) were obtained. The residue, on removal of the volatile oil, was dissolved in ether, dried and ether removed, when a dark viscous mass (B) was obtained.

Examination of the volatile oil :—

The volatile oil (A) had the constants given in the following table :—

TABLE No. 2

Refractive Index at 28°	1.417
Density at 28°	0.8210
Acid value	nil
Acetyl value	146.0
Saponification value	nil
Optical rotation [α] _D	-22

The oil did not contain nitrogen and was free from phenolic, aldehydic and ketonic substances and boiled between 260-280 but no pure product could be obtained from it.

Investigation of the residue (B) :—

The residue (B) was dissolved in petroleum ether when on cooling piperine (30 gms) separated which was removed. On two crystallisations from ethyl alcohol it melted at 129-130 (mixed melting point with an authentic specimen prepared from piper nigrum was unchanged). The petroleum ether from the filtrate was removed and the residue was distilled under reduced pressure. Considerable amount of frothing occurred and it was only after several distillations that about 100 gms. of a clear distillate (D) were obtained. This was redistilled at 20 mm. pressure when the following fractions were obtained :—

TABLE NO. 3

Fraction No.				B. P.	Wt.
D ₁	..	..	..	upto 170°	15 gms.
D ₂	..	..	..	170—210°	25 "
D ₃	..	..	..	210—235°	25 "
D ₄	..	..	..	235—270°	15 "
D ₅	..	..	..	270—286°	15 "
Residue	..	..	..	— —	—

The residue solidified to a dark mass but did not yield any crystalline solid and hence was not further investigated.

Investigation of the fractions of D :—

Fractions D₁ to D₄ were found to be acidic and, therefore, they were dissolved in ether and extracted with 5 per cent sodium hydroxide. The sodium hydroxide layer on acidification gave acids which are described below. The non-acidic layer which remained in ether has been analysed separately.

*Fraction D₁ :—*It gave only a very small quantity of a liquid acid.

*Fraction D₂ :—*Palmitic acid was isolated from this fraction and was identified by its m.p. : 61°, mixed m.p. with an authentic specimen and by the preparation of its anilide m.p. 90-91°.

*Fraction D₃ :—*The acid from fraction D₃ was also a solid.

It was boiled with water and filtered. The water extract on concentration gave a small quantity of a crystalline acid m.p. 101-102°. The acid insoluble in water was shown to be palmitic acid by m.p. and mixed m.p. with an authentic specimen.

*Fraction D₄ :—*The acids from this fraction easily crystallised from water. The equivalent weight was found to be 240 and m.p. 100-101°. This appears to be tetrahydropiperic acid containing one mol. of water of crystallisation. This was confirmed by heating the acid at 100° and finding out the loss in weight. The melting point was unchanged on drying. Borsche (Ber, 44, 2944, 1911) gives the m.p. 100-101° but does not mention the formation of a monohydrate. The anhydrous acid has equi. wt. 222.2, the equi. wt. required for tetrahydropiperic acid being 222.

*Fraction D₅ :—*It did not contain any appreciable quantity of a free acid.

Investigation of the non acidic portions from fractions of D

*Fraction D₁ and D₂ :—*After removal of the acids from fraction D₂ by sodium hydroxide, the neutral portion solidified. This was crystallised several times from alcohol when white glistening flakes (E) were obtained. It had only a faint tingling taste. It melted sharply at 37-38° and did not contain nitrogen or methoxyl group. Fraction D₁ also gave the same substance (E) on refractionation and freezing. The substance absorbed bromine in chloroform solution but the bromide could not be isolated in a crystalline form. Assuming the presence of one double bond in the substance (E), the mol.wt. from the bromine absorbed was found to be 264. The substance (E) has been given the formula (C₁₈ H₃₆ O₂) on the following combustion results :— (Found C, 79.1 ; H, 9.7 per cent. : C₁₈ H₃₆ O₂ requires C, 78.8 ; H, 9.5 per cent.)

Oxidation of (E) :—

5 gms. of the substance (E) were dissolved in 50 ccs. of dry acetone and powdered potassium permanganate (10 gms.) was gradually added. Considerable amount of heat was developed. It was refluxed for 1 hour on a water bath. Acetone was then removed and the residue was suspended in 150 ccs. of water and the manganese

dioxide was dissolved by passing sulphur dioxide. An oily liquid separated, which was taken up in ether, on drying and removing the ether, the residue showed signs of crystallisation. It was then steam distilled when a volatile liquid acid (F) was obtained. Part of it was converted into the silver salt and the analysis of the silver salt showed the equivalent weight to be 182. This may be a mixture of decolic and undecolic acid. The acid was distilled and the main fraction (b. p. 260-270 at 710 m.m.) was converted into the anilide. The anilide melted at 67°, (anilide of decolic acid melts at 68°). The oxidation product, therefore, appears to be probably *n*-decoic acid.

After the removal of the steam volatile acid (F) the residue was concentrated when piperonylic acid m.p. 132-133° was obtained which was confirmed by mixed m.p. with an authentic specimen of piperonylic acid prepared by oxidising piperonal. (Organic Synthesis. Vol. 10, p. 82). The Constitution of the substance (E) appears to be 1-undecylenyl-3:4-methylene dioxy-benzene (Fig. E).

The substance (E) absorbed hydrogen in the presence of Adam's catalyst corresponding to the presence of one double bond. The reduction product, however, was a liquid at room temperature and was not further investigated.

Attempts to synthesise the substance (E) are described below :—

Condensation of undecoyl chloride with methylene dioxy benzene in the presence of anhydrous aluminium chloride.

To a mixture of methylene dioxy benzene (4 gms.) undecoyl chloride (6 gms.) and dry nitro benzene (9 ccs.), was added anhydrous aluminium chloride (9 gms.) in small lots, the whole mixture being cooled in ice and protected from moisture. On allowing it to stand overnight, it was decomposed with ice and hydrochloric acid and nitrobenzene was removed by steam distillation. The residue was dark resinous and dissolved in sodium hydroxide with violet colouration. It seems, therefore, that in this reaction the aluminium chloride has affected the methylene dioxy group and hence the desired product was not obtained. The reaction was not pursued further.

n-Decyl iodide :—This was prepared from the silver salt of undecolic acid and iodine following the method of Mehta and Thosar (J. I. C. S. Ind and News edition, 3, 135, 1940).

Grignard reaction between n-decyl iodide and piperonal :—

n-Decyl iodide (4 gms.) and magnesium filings (0.4 gm) were suspended in dry ether (50 ccs.). The magnesium dissolved on refluxing the mixture for two hours. To this grignard reagent piperonal (2.5 gms) in dry ether solution, was added. It was further refluxed for two hours. It was cooled, and decomposed with ice and dilute sulphuric acid. The ether layer was removed, dried and ether distilled off. The residue was a viscous mass (H), (yield 2 gms.)

Dehydration of (H) :—

The viscous mass (H) could not be crystallised. It was dissolved in 50 ccs. of dry benzene and 5 gms. of phosphorus pentoxide were added to it. The reaction mixture was refluxed for three hours. Benzene layer was filtered off and benzene removed. The residue (I) was crystallised from alcohol in glistening flakes. It had m.p. 36-37°. (C, 78.9; H, 9.8 per cent : C₁₈ H₂₆ O₂ requires C, 78.8, H, 9.5 per cent). Its properties were similar to those of the substance (E) but the mixed melting point with (E) was about 5° lower. This shows that the side chain (C₉ H₁₉) in (E) might be a branched chain.

Fraction D₃ :—This fraction, on refractionation, gave the substance (E) in considerable quantity. The residue from this fraction was mixed with fraction D₄ and D₅.

Fractions D₄ and D₅ :—These were fractionated several times when a comparatively homogenous product (J) pale brown in colour boiling between 240-260° at 12 mm. was obtained. Major portion of it boiled between 245-250°. It had a powerful nauseating odour and taste. It was thought to be piperidide of tetrahydropiperic acid described by Borsche (Ber. 44, 2943, 1911 : B. P. 280 at 16 m.m.) The substance (J) was dissolved in alcohol (50 ccs) and concentrated hydrochloric acid (10 ccs) and was refluxed for eight hours. It was then diluted and extracted with ether. The ether

extract failed to give any crystallisable acid. The acid layer was made alkaline when it had an odour like piperidine. The base, however, could not be isolated by ether extraction. The alkaline solution was, therefore, distilled and the distillate was received in a saturated solution of picric acid in water. Gradually crystals separated which were identified as piperidine picrate by its m.p. 151-152° and mixed m.p. 152 with an authentic specimen.

Hydrolysis of (J) by alkali :—

The substance (5 gms.) was hydrolysed with 25 per cent alkali. On working up as usual it gave tetrahydropiperic acid, m.p. 101-102°. The quantity, however, was small.

The lower boiling point of this fraction and the smaller quantity of tetrahydropiperic acid obtained showed that some other substance was present. This could not be identified.

The remaining residues in different fractions were treated in the same manner when small quantities of liquid acids were obtained by alkaline hydrolysis, but the liquid acids could not be identified.

Since a considerable quantity of the ether extract on distillation under reduced pressure left a dark residue it was thought that it might be due to the presence of a substance which decomposed or polymerised during distillation. A fresh ether extract was examined, therefore, in an alternative way as described below, in which the distillation was omitted.

Examination of the ether extract (Alternative method) :—

The ether extract from 5 kgs of piper longum fruits was dissolved in ether and treated with five per cent sodium hydroxide. The thick emulsion formed was broken by the addition of a few ccs of alcohol. The alkaline layer (K) was removed and was acidified. These acids (35 gms.) were esterified by the usual method and were distilled at 12 mm. pressure. Various fractions (b.p. 180-200°) were collected as usual. The residue was very little and gave semi solid acids which absorbed bromine. From the various fractions of the methyl esters, acids were obtained and they were separated into solid and liquid acids by the usual procedure. Palmitic and stearic acids were identified as the solid acids. The liquid acids from the different fractions were combined together. They had equi. wt. 285 and iodine value 140. On bromination according to Jamieson's method (J. A. C. S., 42, 2398, 1920) and working up as usual, the mixture gave an ether insoluble bromide (m.p. 180-182°), a petrol insoluble bromide (m.p. 114) and a liquid dibromo acid (most probably dibromide of oleic acid).

Examination of the non acidic portion :—

After the separation of the free acids (K), the ether layer was dried, ether distilled off. To the residue petroleum ether was added when a solid was precipitated. The Solid (L₁) on crystallisation from alcohol had m.p. 130-131° and was identified as piperine by mixed m.p. with an authentic specimen.

The petroleum ether soluble fraction (L₂), on removal of the solvent, was distilled under reduced pressure. The first fraction boiled upto 240° at 15 m.m. while the second one boiled at 240-280 at 15 m.m. The first fraction had tingling taste while the second had a nauseating taste but had no tingling taste. Both were hydrolysed by alkali as well as acid. Piperidine only could be identified from the acid hydrolysis. Tetrahydropiperic acid and a water insoluble liquid acid were obtained from the alkaline hydrolysis. The water insoluble liquid acid yielded a small quantity of a bromide insoluble in ether m.p. 180° (about). It was not, however, linolenic acid hexabromide as its m.p. was depressed by about 10° when mixed with an authentic specimen. Obviously it is not linolenic acid but seems to be an easily polymerisable isomeric acid. It polymerises rather readily and, therefore, could not be further investigated.

FRACTIONATION OF THE DIFFERENT TYPES OF PHOSPHORUS COMPOUNDS IN THE PRAWN MUSCLE

BY T. C. APPANNA AND S. C. DEVADATTA

PRAWNS are considered to be a good source of food at par with fish as they supply proteins of high biological value and digestibility coefficient (Appanna and Devadatta, 1942). The prawn muscle also contains a large amount of organic and inorganic phosphorus and it would be of interest to know how this element is distributed in the muscle. In this work a separation of the various fractions of phosphorus in prawn muscle has been effected. A considerable amount of work on the distribution of phosphorus compounds both inorganic and organic forms in the vegetarian and non-vegetarian foodstuffs have been investigated, by many workers.

Kernot and Speer (1933), working on the distribution of phosphorus compounds in the six different species of fish have found that the labile phosphorus compound content varies from eight to twenty mgm. per hundred gm. of the muscle.

Needham and Needham (1932), have done considerable work on the distribution of phosphorus compounds in the invertebrate muscle. The invertebrates studied by them are Coelenterates, Ctenophores, Planarians, Nemertines, Polychaetes and the Holothurians. Only in the case of Coelenterates they could not find the presence of phosphagen, but in all the other invertebrates studied, they were able to demonstrate the existence of phospho-arginine.

The method adopted by Eggleton and Eggleton (1929), on the distribution of phosphorus compounds in the frog muscle, is found to be very useful. Acharya and Devadatta (1939) have successfully adopted this method to study the distribution of the phosphorus compounds in Bombay buffalo milk. In view of the fact that the prawn muscle contains a large amount of phosphorus, a fractionation of the different types of the same was undertaken. Four varieties of the prawns called by the following local names, Sode I, Sode II, Tendli and Golim were selected for investigation.

EXPERIMENTAL

Compounds of phosphorus in the acid-soluble portion of the prawn muscle were estimated by employing the method developed by Eggleton and Eggleton (loc. cit.) for muscle tissues.

To obtain the acid-soluble portion of the prawn muscle, one gram of the edible portion was weighed accurately and finely minced in a mortar. To this water and 2 cc. of 20% trichloroacetic acid were added and triturated well until deproteinization was complete. The volume was made up to 25 cc. and centrifuged. Protein coagulum was separated and the acid extract containing acid-soluble phosphorus was neutralised by the addition of finely ground solid baryta until neutral to phenolphthalein (i.e., pH 9). This mixture was centrifuged and decanted. The liquid (Fraction B) was separated from the precipitate (Fraction A) which was redissolved in a drop of concentrated hydrochloric acid and diluted to 10 cc. with water.

Fraction A

This contains the inorganic and the difficulty hydrolysable organic phosphorus compounds. The ortho-phosphate in this liquid was estimated by the direct application of Brigg's method (1922) before any hydrolysis had set in. The pyro-phosphate was next estimated by Lohman's method (1928). The organic phosphorus was estimated after the solution was oxidised by 100 volumes hydrogen peroxide and sulphuric acid and hydrolysed. In all these estimations a quantity of extract expected to contain 0.15 to 0.2 mg. of phosphorus was used.

Fraction B

This contains organic phosphorus compounds soluble in barium hydroxide at pH 9—hydrolysable and non-hydrolysable at ordinary temperature. To estimate the amount of the hydrolysable organic phosphorus, the extract was hydrolysed with 2 cc. of 5.5 N Sulphuric acid for sixty minutes at ordinary temperature before the application of Brigg's method. To determine the amount of phosphorus associated with the non-hydrolysable phosphorus compound, the total amount of phosphorus in fraction B was estimated after oxidation and hydrolysis referred to already. The difference between this amount and that due to hydrolysable variety gives the non-hydrolysable organic phosphorus compound present in the muscle.

Total phosphorus in the muscle and in the acid insoluble portion in the protein coagulum were separately estimated, after complete oxidation and hydrolysis. Therefore it has been possible to check up some of the values obtained by indirect method. Wherever possible the values obtained by direct estimations were compared with those obtained by difference and found to agree within the experimental error.

RESULTS AND DISCUSSION

TABLE I

*Concentration of different types of Phosphorus compounds in the Prawn muscle
(mg. per 100 gm. of the muscle)*

Local Name	Scientific Name	Total P.	Total Acid P. (sol.)	Total Acid Insol. P.	Fraction B			Fraction A	
					Easily hyd. org. P. Sol. in Ba (OH) ₂ at pH 9	Non-hyd. org. P. Sol. in Ba (OH) ₂ at pH 9	Non-hyd. org. P. Insol. in Ba (OH) ₂ at pH 9	Orth. P.	Pyro. P.
Sode I ..	Parapaencopsis Sculptilus ..	177.0	161.0	15.40	78.65	19.65	7.14	25.54	28.12
Sode II ..	Parapaencopsis Uncta ..	170.20	154.2	15.10	72.56	16.24	10.52	29.56	30.32
Tendli ..	Metapencus Monoceros ..	159.5	140.4	18.90	62.23	17.51	8.36	27.06	28.65
Golim ..	Leander Styli-ferus ..	130.0	116.5	13.70	58.50	11.70	6.24	19.50	22.10

TABLE II

Compounds of phosphorus expressed as percentage of total Phosphorus in 100 gm. of muscle

Local Name	Total P.	Fraction B			Fraction A	
		Easily hyd. P.	Non-hyd. P.	Non-hyd. P.	Ortho P.	Pyro P.
Sode I ..	177.00	44.40	11.10	4.30	14.42	15.58
Sode II ..	170.20	42.63	9.54	6.17	17.36	15.42
Tendli ..	159.50	39.01	10.09	5.20	16.90	17.90
Golim ..	130.00	45.00	9.00	4.80	15.00	17.00

In the acid soluble portion of the muscle as could be seen from the Table II nearly 58% of phosphorus is in the organic form of which fraction B comprises about 53%.

Fraction B

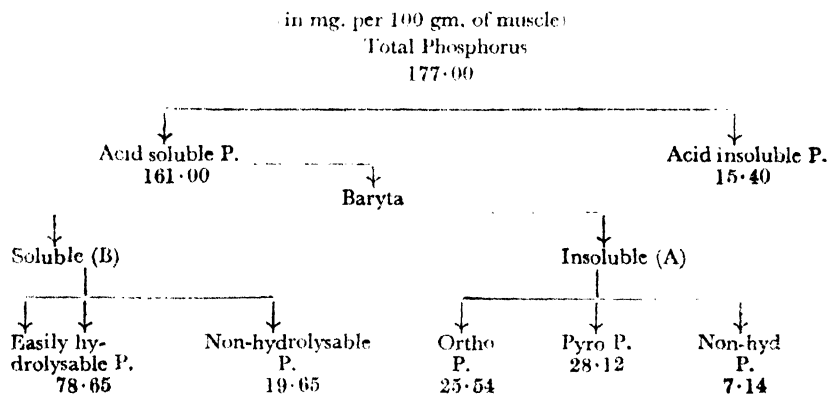
This fraction (which is soluble in barium hydroxide at pH 9 and which contains organic phosphorus compounds) exists in two forms (1) directly estimable by Brigg's method and (2) estimable after oxidation and hydrolysis. The former constitutes 44.40, 42.63, 39.01 and 45.00%, and the latter 11.19, 9.54, 10.90 and 9.00 percent of total phosphorus. Kay (1931) observed an increase in phosphorus content of the trichloroacetic acid extract of liver of rats which has been in contact with acid for several hours. He attributed this to the hydrolysis of phospholipids. The esters of phosphorus group i.e., those found to be barium hydroxide soluble, were supposed to be glycerophosphates. Eggleton and Eggleton (loc. cit.), state that this fraction contains along with creatinephosphoric acid few hexose—mono, and di-phosphoric acid esters.

Fraction A

In Tables I and II are given the amount of the compounds of phosphorus insoluble at pH 9 in presence of barium hydroxide. It will be seen that the fraction is divided into three types; ortho, pyro and non-hydrolysable phosphorus. From the Table II, it is seen that ortho phosphorus comprises 14.42, 17.36, 16.90 and 15.00% (respectively) and pyro phosphorus 15.80, 15.42, 17.90, 17.00% (respectively) of the total phosphorus per 100 gms. of muscle.

It will be seen from the above discussion that it has been possible to establish the existence of five independent types of phosphorus compounds: Ortho, pyro, organic phosphorus compounds insoluble in barium hydroxide at pH, 9, hydrolysable and non-hydrolysable organic phosphorus compounds soluble in Ba (OH)₂ at pH 9.

SCHEME SHOWING THE DISTRIBUTION OF PHOSPHORUS IN SOLE I



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A STUDY OF THE NUTRITIVE VALUE OF PROTEINS AND MINERAL CONTENTS OF SOME VARIETIES OF FISH FOUND IN BOMBAY

BY S. C. DEVADATTA AND K. S. VARADAN

PART I

FISH constitute a cheap source of animal proteins. Since a happy blending of good flavour with cheapness is found in fish, large quantities of fish are consumed by the public. Hence it is highly desirable to find the nutritive value of fish. Four varieties which are very popular in Bombay are selected for the present investigation.

A general analysis of these fish, Bombil, Halva, Pomphret and Waam have been made. The amount of fat was determined by the extraction of the dried muscle with ether. The proteins were estimated by the usual Kjeldhal's method. The ash was estimated by Stoltes method described by Peters and Van Slyke (1932). Brigg's modification of Bell and Doisy method (1922) was used in the estimation of phosphorus. Calcium was determined by the volumetric permanganate method described by McCrudden (1909, 1911) and iron according to Kennedy (1927). The results obtained are given in Table I.

TABLE I

Analysis of the Fish

Popular Name	Scientific Name	Contents per 100 grams of Edible Portion						
		Moisture gm.	Proteins gm.	Fat gm.	Ash gm.	Calcium mgm.	Phosphorus mgm.	Iron mgm.
Bombil	Harpodon Nchereus	88.94	8.24	0.79	0.81	78.12	95.63	0.033
Halva	Stromateus Niger	74.3	20.89	2.87	1.54	188.5	154.2	1.420
Pomphret	Stromateus Cinereus	75.3	17.72	0.8	1.16	142.0	137.8	1.630
Waam	Muraenox Cinereus	80.12	17.58	0.24	1.14	167.3	177.0	..

A glance at table I will show that these fish contain considerable amounts of calcium and phosphorus. They may furnish an important source of the mineral requirements of the body. Hence it was thought desirable to find the amount of phosphorus and calcium in soluble form which may be easily utilized by the body for absorption and assimilation. For this purpose a modified scheme of Arney (1939) was made use of. A known amount of the dried muscle was extracted with water and the minerals calcium and phosphorus estimated in the aqueous extract. The residue was treated with trichloroacetic acid and the estimation of the minerals in the acid extract was carried out. These two results should denote the amounts of calcium and phosphorus present respectively in water-soluble and acid-soluble portions of the fish muscle. A procedure to verify the results obtained above was resorted to. This consisted in directly treating the dried muscle with trichloroacetic acid. This acid extract should contain water and acid soluble fractions of calcium and phosphorus of the muscle. The residue left over after extraction with trichloroacetic acid was ashed and the minerals estimated. This represented the amount of minerals in acid-insoluble fraction of the muscle.

The amount of calcium and phosphorus estimated in the ash of the muscle (Table I) should now correspond to the sum of those present in water soluble, acid soluble and acid insoluble portions of the muscle extract.

Table II contains the amounts of phosphorus present in water soluble, acid soluble and acid insoluble conditions.

TABLE II

Name	Scientific Name	Phosphorus in mgms. per 100 gms. of Fish						
		Water soluble	Water insoluble but acid soluble	Total acid soluble		Acid insoluble	Total Phosphorus	
				Calculated	Estimated		Calculated	Estimated
1	2	3	4	5*	6	7	8*	9
Bombil	Harpodon Neherens	46.22	25.30	71.52	72.05	24.24	96.29	95.63
Halva	Stromateus Niger	91.75	26.06	117.81	117.80	37.27	155.07	154.19
Pomphret	Stromateus Cinereus	88.81	25.98	114.79	109.80	24.90	134.7	137.80
Waam	Muraenox Cinereus	56.52	67.92	124.44	128.60	56.18	184.78	177.00

* Column 5 is obtained by adding Cols. 3 and 4 and Col. 8 by adding Cols. 6 and 7.

Similarly Table III denotes the amounts of calcium present in water soluble, acid soluble, acid insoluble, fractions of the muscle extract.

TABLE III

Name	Scientific Name	Calcium in mgms. per 100 gms. of Fish						
		Water soluble	Water insoluble but acid soluble	Total acid soluble		Acid insoluble	Total Calcium	
				Calculated	Estimated		Calculated	Estimated
1	2	3	4	5*	6	7	8*	9
Bombil	Harpodon Neherens	13.27	33.18	46.45	46.45	30.74	77.19	78.12
Halva	Stromateus Niger	33.15	111.20	144.35	144.30	43.18	187.48	188.50
Pomphret	Stromateus Cinereus	80.02	29.64	109.66	110.70	31.60	142.30	141.90
Waam	Muraenox Cinereus	24.53	43.52	68.05	67.26	99.6	166.86	167.5

It is seen from these tables that the amount of phosphorus (and calcium) in total acid soluble fraction of the muscle estimated directly agrees with the value calculated from the sum of the amounts of phosphorus (and calcium) present in water soluble and "only-acid" soluble fraction of the muscle.

Also the total amounts of calcium and phosphorus agree with the sum of the respective minerals in acid soluble and acid insoluble state. The error involved in these cases vary from 0.00 to 3.00% thus showing the reliability of the method.

For purposes of comparison the amounts of phosphorus and calcium present in different forms are expressed as percentages of the total minerals in the following tables IV and V respectively.

TABLE IV

Different forms of Phosphorus expressed as percentage of Total Phosphorus

Name	Scientific Name	Water soluble	Only acid soluble	Acid insoluble
Bombil	Harpodon Neherens	48.33	26.45	25.24
Halva	Stromateus Niger	59.36	16.9	24.16
Pomphret	Stromateus Cinereus	64.90	18.86	16.802
Waam	Muraenox Cinereus	31.93	38.33	31.74

* Col. 5 is obtained by adding Cols. 3 and 4 and Col. 8 by adding Cols. 6 and 7,

TABLE V

Different forms of Calcium expressed as percentage of Total Calcium

Name	Scientific Name	Water soluble	Only acid soluble	Acid insoluble
Bombil	Harpodon Neherens ..	16.99	42.46	39.33
Halva	Stromateus Niger ..	17.58	58.98	22.91
Pomphret	Stromateus Cinereus ..	56.40	20.89	22.39
Waam	Muraenox Cinereus ..	14.64	25.98	59.47

The acid extract contains calcium and phosphorus in the form of organic esters (which are not hydrolysed), besides their inorganic compounds. Phospho-proteins and phospho-lipides would be represented by the acid insoluble fraction. The water extract would mainly represent soluble calcium phosphate.

It will be seen from table IV that about 50% of the total amount of phosphorus present in all these cases is found in inorganic state. In the case of Pomphret the percentage of inorganic phosphorus is as high as 65%, while the acid insoluble phosphorus is found to be very low 16.8%. Whereas Waam contains the element equally distributed in water, acid and acid insoluble portions. Pomphret is regarded as one of the best fish available, and the above findings may possibly be one of the reasons for this.

As far as calcium is concerned the water soluble fraction of the muscle contains only a small percentage of it except Pomphret which contains 56% of calcium in the water soluble fraction. It may be noted that Halva and Pomphret contain 77% of calcium in the acid soluble portion whereas Bombil and Waam contain 59 and 40% respectively. Waam has nearly 60% of its calcium in the acid insoluble form. Thus Halva and Pomphret, the most popular fish in Bombay have the elements phosphorus and calcium in the soluble form in which they are easily absorbed into the system of the consumers.

PART II

Biological assay of proteins is undertaken to corroborate the statements made in Part I.

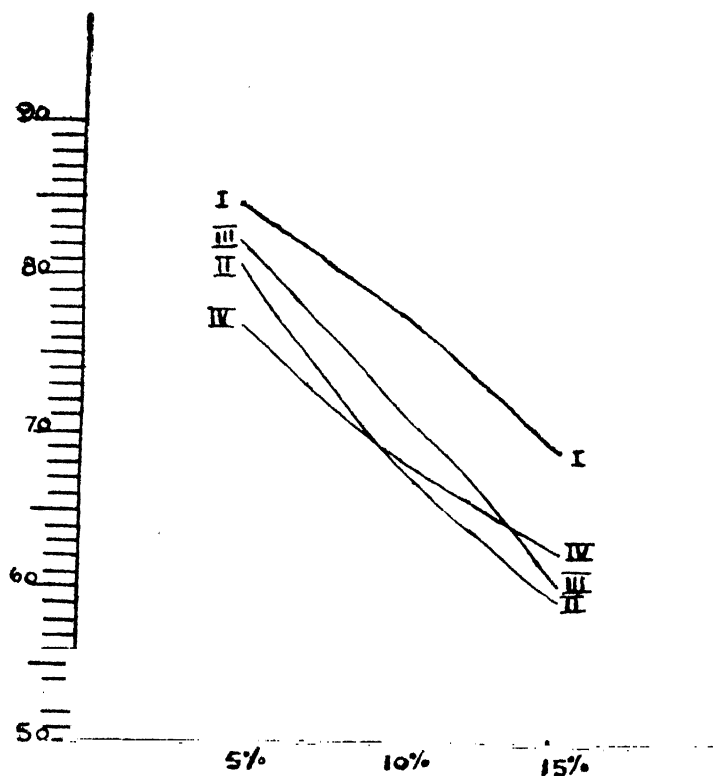
A glance at Table I will show that these fish under investigation are fairly rich in protein and hence the nutritive value of their proteins was investigated. The Biological value and Digestibility coefficient of proteins of these fish muscles were determined at different levels of protein intake, (5, 10 and 15%). The method adopted was that described by Mitchell (1924) and Chick et al (1935). The results obtained are given in Table VI.

TABLE VI

Biological Value and Digestibility Coefficient of Fish

Name	Scientific Name	Level of protein intake	Biological value	Digestibility Coefficient
Bombil	Harpodon	5%	84.50	84.10
	Neherens	10%	77.65	84.90
		15%	68.65	84.5
Halva	Stromateus	5%	80.70	85.03
	Niger	10%	67.61	82.60
		15%	59.43	75.81
Pomphret	Stromateus	5%	82.11	84.01
	Cinereus	10%	71.21	86.29
		15%	60.08	70.76
Waam	Muraensox	5%	77.01	80.03
	Cinereus	10%	68.47	84.60
		15%	62.12	70.41

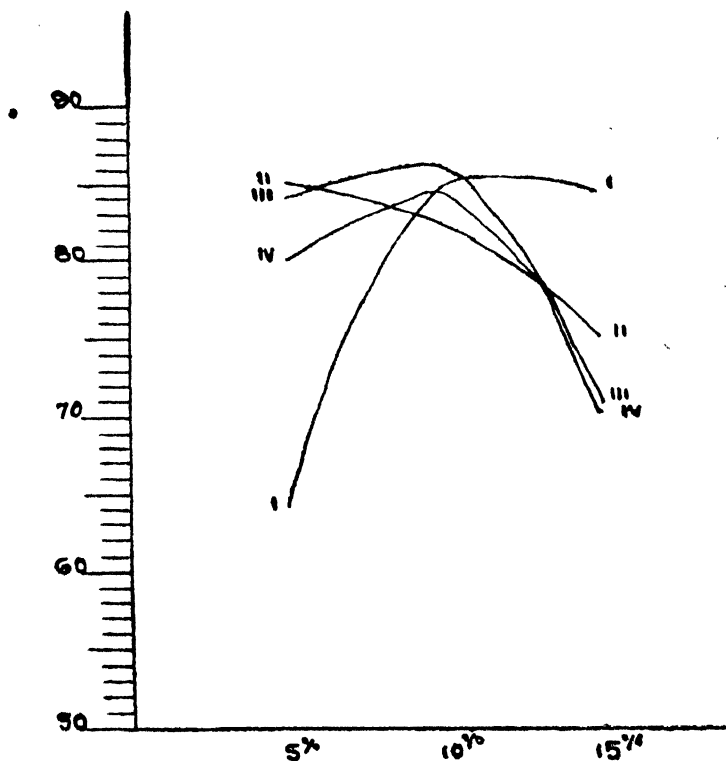
The results show that these fish contain proteins of high biological value and digestibility coefficient.



GRAPH I—Biological Value

I—Bombil. II—Halva. III—Pomphret. IV—Waam.

It can also be observed that biological value and digestibility coefficient vary with the level of protein intake. These variations are best illustrated by graphs. Graphs I and II represent the curves of biological value and digestibility coefficient of the fish at different levels of protein intake. It is seen that in all cases (Graph I), the biological value decreases with increase in the concentration of proteins in the diet. This is in conformity with the results of other workers, Boas Fixsen (1932), Niyogi et al (1931), (a) and (b) and Acharya et al (1942).



GRAPH II—Digestibility Coefficient

I—Bombil. II—Halva. III—Pomphret. IV—Waam.

It is seen from graph II that the digestibility reaches the maximum value at ten per cent level of protein intake in all the cases studied. This may indicate that maximum digestibility is secured when protein forms ten per cent of the food taken. But since there is a rapid fall in the biological value care should be exercised in choosing an optimal level of protein intake to secure maximum benefit.

To find this optimal level of intake, the curves of the biological value and digestibility coefficient for the same fish at different levels of protein intake were drawn on graph papers. The point of intersection of these two curves represented the optimal level of intake. In table VII are given the results obtained in this manner.

Name	Scientific Name	Optimal level
Bombil	Harpodon Ncherens	8.5%
Halva	Stromateus Niger	4%
Pomphret	Stromateus Cinereus	4.75%
Waam	Muraensox Cinereus	4.5%

The optimum level of protein intake in the three fish, viz., Halva, Pomphret and Waam is found to be between 4% and 5%. This shows that these fish form an economical source of animal proteins. Bombil, whose optimum level is 8.5, is uneconomical as it contains a lower percentage of protein when compared to the other three. Waam which has rather low available mineral content can be compared favourably with other popular fish Halva and Pomphret with respect to its protein contents.

SUMMARY

The nutritive values of proteins and mineral contents of the fish Bombil, Halva, Pomphret and Waam have been studied. They are found to be rich in the essential minerals calcium and phosphorus. The estimation of the amounts of the elements present in different forms was carried out. Halva and Pomphret are found to contain more than 70% of the minerals in soluble state which can be utilized easily by the body.

The proteins of the fish are found to possess high biological value and digestibility coefficient. They can be advocated as cheap sources of animal proteins as well as of minerals calcium and phosphorus.

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PHENOMENA OF HIGH FREQUENCY DISCHARGE

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INTRODUCTION

FOR the last twenty years considerable work has been done on the electrical and spectral characters of h.f. discharge in gases at low pressure. The workers in the field have investigated the various aspects under varied experimental conditions. A connected account of these investigations is not available in any publication or review. Sir J. J. Thomson in his classical text book "Conduction of Electricity through Gases" (Part II) has only treated the electromagnetic aspect of the *ring electrodeless discharge* and the account given by him is restricted only to his own investigations on the subject. Loeb's recent treatise "Fundamental Processes of Electrical Discharge in Gases" is a most exhaustive and classical work yet obtainable on the subject. It makes a brief reference to the work on h.f. discharges under the heading *spark breakdown with alternating current*; but the subject being involved cannot naturally be treated in detail in a book dealing with fundamental processes. As no connected account is available of the subject, it is not possible to form a correct estimate of the present position of the subject of h.f. discharges. The literature is scattered in numerous papers published since 1884. Very few investigations have been undertaken under absolutely defined conditions and most of them are not helpful in understanding the nature of the discharge, because some of the important parameters are not known. In the following pages is given a brief account of these various investigations. More stress is particularly laid on the aspects not so far incorporated in text-books and an exhaustive bibliography given at the end will prove useful to readers wishing a closer approach to the subject.

CLASSIFICATION OF THE H. F. DISCHARGES

The various forms of the h.f. discharges, can be classified into two different forms according to their method of excitation. They are :

(A) The gas at low pressure may be contained in a tube round which a coil of wire is placed. The discharge is then excited by means of field due to the h.f. current flowing through the coil [Fig. 1(a)].

(B) The discharge may be produced between two electrodes maintained at h.f. alternating potential difference. The electrodes may be placed inside or outside the tube containing the rarified gas, [Fig. 1(b)].

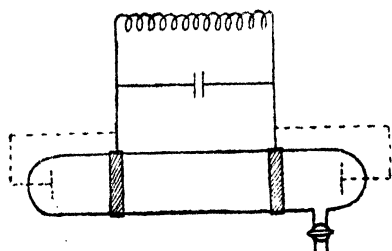


FIG. 1(a)

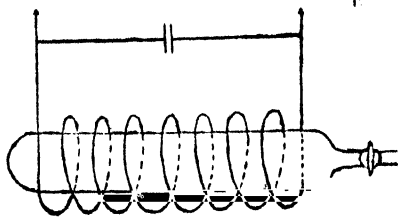


FIG. 1(b)

The type of discharge excited by method (A) is generally known as the h.f. electrodeless discharge. This term *electrodeless discharge* has however been used by some workers for the other type of h.f. discharge excited by placing metallic electrodes outside the discharge vessel but in contact with the glass walls as mentioned in (B) above. This h.f. discharge with external electrodes has none of the characteristics of what is termed as *electrodeless discharge* as classified in (A) above; it is more like the ordinary discharge with its cathode dark spaces and other characteristics. This discharge between two electrodes looks as if a pair of ordinary glow discharges has been placed end to end, extending towards both the electrodes from a common positive column, midway between the two electrodes. Both the electrodes act as if they are cathodes. Between the positive column and either electrode we have the usual Faraday dark space, negative glow and the cathode dark space. The electrostatic glow in the h.f. electrodeless discharge at lower excitation due to the electrostatic field of the solenoid is similar in its mechanism to the glow in h.f. discharge with external electrodes; but the distribution of field in the discharge space is entirely different in the two cases. Under favourable conditions the electrodeless discharge takes the form of bright rings and has been called *the ring electrodeless discharge* by Sir J. J. Thomson.

For the sake of clear representation the various investigations on the two types have been classified as under :

- (i) Those concerned with the initiation and maintenance of the discharge.
- (ii) Those concerned with the energy of the electrons occurring in the discharge.
- (iii) Miscellaneous : Those concerned with the qualitative study of the nature of the striations, the appearance and colour of the discharge.
- (iv) Those concerned with the spectral nature of the radiations emitted by the discharge.
- (v) Those concerned with the chemical reactions occurring in the discharge.

The above mentioned classes of investigations have been carried out by numerous workers with both types of excitations, *viz.*, (A) and (B). It is proposed to take a review of the first three types of investigations below separately for excitation (A) and (B). The spectroscopic and chemical investigations form independent subjects by themselves and will not be attempted here.

(A) ELECTRODELESS DISCHARGE

(i) *Initiation and Maintenance*

Although the electrodeless discharge was discovered as early as 1884 by Hittorf,¹ there were conflicting views about its origin till about 1932. The earlier workers Lehrmann,² Tesla,³ Steiner,⁴ etc., gave experimental evidence that this discharge was due to the electrostatic force caused by the potential difference between the ends of the coil carrying the h.f. current, while Hittorf thought that the initiation was the result of the electromagnetic force, *i.e.*, force due to the change of magnetic field. Mierdel⁵ in his paper on h.f. discharge has given a complete account of these investigations and has given a list of the earlier important papers.

This controversy about the origin of the electrodeless discharge later engaged the attention of two important groups of workers, one under Sir J. J. Thomson and the other under Townsend. J. J. Thomson⁶ in 1927, using excitation by Spark discharge, (*damped oscillations*) gave additional evidence supporting the view of the electromagnetic origin (which he has always held) originally postulated by Hittorf. Thomson's work was confined to the ring electrodeless discharge which occurs within a short range of pressures and he worked out a theory for this discharge on the electromagnetic basis. This theory has been completely treated in Thomson's classical text-book on the subject. He has described this discharge as "a discharge with closed lines of force, with no electrodes and no need for any regenerative process to renew the supply of electrons." Thomson's work was followed by that of Townsend and Donaldson⁷ who criticised the electromagnetic view. These authors excited electrodeless discharge in cylindrical tubes and spherical bulbs using *undamped oscillations* from a valve oscillatory circuit. They have shown that the electrostatic field due to the solenoid is generally much greater than the electromagnetic field and have thus concluded that the electrodeless discharge is of electrostatic origin. Townsend and Donaldson have determined the striking and maintenance potentials for frequencies round about 10^6 cycles/sec.

Considerable amount of work has been done in view of the controversy as to (1) the origin of the initial ionisation and (2) the nature of the h.f. discharge. Thomson proposed the electromagnetic origin, while Townsend and his collaborators supported the view of electrostatic character. (It should be made clear that Thomson's work was carried out using damped oscillations while the Townsend school worked with undamped oscillations). MacKinnon's experiments⁸ with excitation circuits energised by damped as well as undamped oscillations showed that the discharge is of electromagnetic character when excited by damped oscillation while it is of electrostatic nature when excited by undamped oscillations. With large currents in the undamped oscillator coil, he was able to demonstrate the bright glow, not reported by Townsend and Donaldson⁷. This glow, he thought, was similar to that of Thomson's ring electrodeless discharge. Brasfield⁹ has shown that the functioning of the electrodeless discharge primarily depended on the potential difference between the two ends of the exciting coil and not on the current through the coil. The discharge ceased when a shield was used to reduce the electrostatic field, showing that it

has an electrostatic origin. Knipp's study¹⁰ of the electromagnetic as well as the electrostatic component of the electrodeless discharge, revealed that the faint glow in the discharge has electrostatic while the bright rings have electromagnetic origin. He worked with obstacles in the discharge tube and was able to obtain separate shadows resulting from the faint electrostatic glow and the bright electromagnetic rings. Smith, Lynch and Hilberry¹¹ investigated the electrodeless discharge in mercury vapour. Their curves relating the starting current with pressure, when examined in the light of Thomson's electromagnetic theory,⁶ revealed that the theory is only applicable for the bright ring discharge and not for the faint glow discharge. Esclangon¹² has also shown that there exist two different regimes in the electrodeless discharge. The first is with a faint glow occurring at lower excitation current, while the second is the bright ring discharge obtainable only at high currents. The induced field is incapable of starting the discharge, but can maintain the second regime once started.

Braun¹³ measured the critical pressure and the critical current values for the initiation of the electrodeless discharge and investigated their dependence on the frequency of excitation. He has obtained an expression giving the relationship between the initiation current, the maintenance current, frequency and pressure at which the discharge is operated. Steinhäusser¹⁴ has also measured the critical pressure and critical current for the striking of the discharge in various gases. He has discussed the free life period of the electrons in the discharge in the light of the differences noticed in the experiments with damped and undamped oscillations. Yarnold¹⁵ has studied the relative importance of the electrostatic and the electromagnetic fields of the solenoid forming a part of the oscillatory circuit for the production of the electrodeless discharge. In his experimental arrangements he was able to nullify the electromagnetic field. He found that the minimum starting and maintenance potentials were not effected by the absence of the electromagnetic field. The electrostatic field was reduced in the second set of experiments by putting shields. Relative measurements of the fields showed that the electrostatic field is by far the greater. The electrodeless discharge is due to the electrostatic force for low currents, but at higher currents, the electromagnetic force becomes appreciable, in fact, comparable with the electrostatic force.

Townsend¹⁶ extended his theory of the uniform positive column to the case of electrodeless discharge. He has made some assumptions to simplify the treatment and has found that the theory may be applied to the h.f. electrodeless discharge within a certain range of pressures. He has also discussed the conclusions in the light of the spectra obtained from the discharge. Yarnold¹⁷ has in his second paper, treated Townsend's extension of the above theory. He has found good agreement between the theoretical and experimental results for smaller currents. The deviation between experimental and theoretical results at higher current, is, however, due to bright electromagnetic discharge. J. Roig¹⁸ has studied the electrodeless discharge by observing the grid and the anode current in the valve of the h.f. oscillator. He found that for small plate voltage these currents were small and the discharge has a weak intensity, but at higher current, the discharge becomes very bright. He also concluded that the discharge with a weak glow is electrostatic while the same with the bright glow is electromagnetic in nature.

The result of these investigations on the initiation and maintenance of the h.f. electrodeless discharge, as described above clearly show that both electrostatic as well as electromagnetic actions occur in the discharge. The relative importance of these depend on the conditions of excitation. The electrostatic force is of course responsible for the initiation of the discharge. It is only when the discharge is struck that the electromagnetic force is experienced by the gas ions. The bright ring discharge is largely due to the electromagnetic force, but requires the electrostatic force for its initiation. For higher currents especially in the case of damped oscillations, the magnetic field predominates in the ring discharge. The electrostatic field tries to move the electrons towards the walls of the tube while the electromagnetic force drives them in circular paths about the field line at various distances from the axis of the tube (inside the tube). Thus the electrons moving under the electrostatic field have a glass wall to strike at either end of their path, while those moving in the influence of the electromagnetic force meet no obstruction in the path. The mean free path of the electrons, i.e., pressure, will therefore to a great extent govern the nature of the discharge. If for the pressure, for which electromagnetic ring discharge takes place readily, the m.f.p. of the electrons be greater than the distance between the glass walls in the electrostatic path, no electrostatic glow will occur even if the electrostatic force be much larger than the electromagnetic force due to exciting coil. For short free paths, i.e., high pressures, the high electrostatic field between the ends of the coil will produce intense ionisation and excitations, but the electromagnetic field will not be able to predominate and cause the ring discharge as the electrons will have collisions before acquiring high velocities. This has been clearly demonstrated by MacKinnon's experiments⁹ where he has shown that the electrodeless discharge through iodine at high pressures shows the yellow electrostatic glow, but at low pressures it passes on to the bright green ring discharge.

In all the cases electrostatic force is required to initiate the discharge. The nature of the discharge after initiation is governed by the pressure and the maximum peak value of the current in the first half of the cycle of oscillation. The r.m.s. value of the current in damped as well as undamped oscillatory circuits may be the same, but the maximum peak value of the current in the first half cycle in the case of damped oscillations, (spark circuits) will be enormously greater than that in the case of undamped oscillations; the electromagnetic field being, therefore, great in the first case (damped oscillations). This will make ring discharge easily excitable with damped oscillations and lower pressures.

When electrodes are present inside the discharge vessel the ionisation is largely electrostatic. For external electrodes placed on the glass, the high frequency conductivity of the glass wall reduces the electrostatic action and complicates the mechanism of the discharge.

(ii) *Energy of the Electrons*

There have been very few attempts to determine the mean energy of the electrons in the electrodeless discharge. A direct determination of the mean energy of the electrons in electrodeless discharge through mercury vapour has been attempted by Smith¹⁰. The discharge

was excited by oscillations of frequency of 890 cycles/sec. at 10^{-4} mm. pressure. Probe measurements were carried out with a cylindrical probe and a hot filament acting as the other internal electrode called the auxilliary-probe for referring the probe potential. The study revealed an electron temperature of 300,000°K at the peak of the wave of energisation. The aim of the investigation was to extend the parameters of Hg vapour into regions of lower pressure and high degree of ionisation. The author has not given any critical study to examine the applicability of probe method to electrodeless discharge, and the investigation does not help to interpret the mechanism of the discharge. There has been no other attempt to directly measure the energy of the electrons in the electrodeless discharge.

(iii) *Miscellaneous*

Many other investigations have been undertaken on electrodeless discharge. The miscellaneous investigations of Sir J. J. Thomson are all well described in his text-book. He has discussed his experiments on the effect of ultra-violet light on the ring discharge. The effect of traces of impurities on the discharge can also be studied in electrodeless excitation, especially at different stages of excitation. Thomson⁶ could demonstrate very small traces of sulphur in this fashion. Striations have been observed by Thomson,⁶ Rohde²⁰ and others; but no particular study of these is on record.

Electrodeless ring discharge has been found to be of great value in studying the chemical and other after effects producing the after-glow. This discharge has been a favourite source for the excitation of spectra by many workers. As these aspects do not concern us much here it is thought not to dilate on these points.

(B) H. F. DISCHARGE WITH EXTERNAL OR INTERNAL ELECTRODES

The h.f. discharge using two external electrodes at a h.f. alternating potential difference, (Electrodes placed outside but in contact with the glass walls) was first excited by Wiedemann and Ebert²¹ in 1893. Systematic study was not undertaken for a very long time. The development took place with the technique of production and measurement of high frequency potential.

(i) *Initiation and Maintenance*

The striking or the initiation potential V_s has been defined by all the workers as the potential difference between the electrodes sufficient to excite luminosity in the tube and the maintenance potential V_m as the one, below which the discharge cannot be maintained. Hulbert²² was the first to study h.f. discharge produced by undamped electric oscillations from a 50-watt oscillating electron tube. He measured the striking potentials for oxygen and hydrogen contained in cylindrical tubes with internal electrodes, and studied the variation of this potential for gas pressures ranging from 1 to 5 mm. of Hg. He found that for a specified pressure and electrode separation the value of the striking potential was independent of the frequency for the range 60 to 10^6 cycles/sec.

Gutton, Mitra and Ylostalo²⁸ investigated the variation of the striking potential V_s with frequency and gas pressure p (frequency 60 to 10^6 cycles/sec.). The value of V_s was found, as the pressure was increased, to decrease rapidly at first and then pass through a minimum value and then increase. Working with tubes fitted with internal as well as external electrodes, they found a marked difference in the value of V_s in the two cases. C. Gutton²¹ extended the above work in dry air and obtained the V_s - p curves for different frequencies. It was noted that for any frequency below a minimum, the voltage passed through a minimum when the pressure is increased, but for any frequency above this critical value, it diminished continually with pressure. At a frequency corresponding to 27m. (wave length) there existed a minimum while at 25 m., there was no minimum. The pressures were varied between 0.5 to 0.05 mm. of Hg. Kirchner^{23, 26} studied the variations in the striking potentials V_s and maintenance potential V_m in air, oxygen, hydrogen and neon. The tube was fitted with internal electrodes and was provided with an incandescent filament. For frequencies round about 10^7 cycles/sec. he measured the striking potential for different pressures and electrode separations. At high frequencies the discharge could be struck and maintained at surprisingly low voltages. This Kirchner attributed to the increased (cumulative) ionisation by electrons swinging to and fro in the h.f. alternating field. Kirchner observed great irregularities in the value of V_s i.e. abrupt change of V_s from 160 volts to 640 volts for air at a pressure of 0.01 mm. of Hg.

Hiedemann²⁷ in 1928 did some important experiments with discharges excited with damped as well as undamped oscillations. He got the V_s - p curves for hydrogen, using discharge tubes with internal electrodes. These curves are not very regular and are found higher in the scale of potential for higher frequencies. These results are quite opposite to those obtained by Gutton^{21, 24} and Kirchner.²⁵ Gill and Donaldson²⁸ measured the potential required to maintain a certain small current in the h.f. discharge in hydrogen using tubes fitted with internal electrodes. They have compared the curves, representing this potential as a function of the pressure of the gas for (i) direct voltage, (ii) voltage alternating at 2×10^5 cycles/sec. and (iii) Voltage alternating at 4×10^7 cycles/sec. The absolute value of the potential required to maintain a certain small current in a gas was greatly reduced when oscillations of very high frequencies were used. At very low pressures the maintenance potential was only a few volts. Townsend and Donaldson⁷ also measured the critical potentials V_s and V_m for h.f. discharge in spherical bulbs with two rings of lead foil forming the external electrodes. They also excited the discharge in cylindrical tubes with external sleeve electrodes. For neon it was found that the maintenance potential V_m was about one-sixth of the striking potential V_s . Small traces of impurities were found to affect the colour of the discharge especially in neon and helium. These authors investigated the dependence of V_s and V_m on the tube diameter and electrode separation and found that the electric force required to maintain the glow column of the h.f. discharge was independent of the distance between the electrodes. Townsend²⁹ subsequently found that the electric force, required to maintain the glow column of the h.f. discharge in cylindrical tubes, was independent of the distance between the electrodes, the amplitude of the current and the frequency of excitation. He developed a theory of the uniform glow column of the h.f. discharge. This theory

indicates that the electric forces in the glow columns of h.f. and d.c. discharge will be the same if both the discharges are excited under identical conditions.

C. & H. Gutton³⁰ were the first to study the variation of V_s and V_m for h.f. discharges at frequencies of the order of 10^8 cycles/sec. The appearance of the discharge at these frequency was different from the one at low frequencies and the V_s - p curves were of different nature. The experiments were done with hydrogen and the frequencies used were between 10^4 — 10^9 cycles/sec. The colours of the glow column and negative glow which showed dissimilarity at low frequencies were found to be the same at high frequencies.

Hayman³¹ has published the V_s - p curves for helium and neon for h.f. discharge excited in cylindrical tubes (external electrodes). Townsend and Nethercot³² have extended the work of Townsend and Donaldson⁷ and determined the potentials required to maintain currents of different amplitudes in h.f. discharge. The discharge tubes were cylindrical and fitted with external electrodes. The potential was found to increase with the current, but for a certain current the rate of increase of the current with electrode separation, was found to be constant for a large range of pressures and frequency showing that the results were in agreement with Townsend's theory²⁹ of the uniform glow of the h.f. discharge. Jones³³ also found that mean electric force in the uniform glow column of h.f. discharges was the same as that in the d.c. positive column. The h.f. discharge in helium was excited in cylindrical tubes with moveable external sleeve electrodes. The electric force was calculated from the increase in applied voltage (to maintain the same current) for an increased electrode separation. Brasefield³⁴ found the conductivity of the h.f. discharge in hydrogen by measuring the voltage required to maintain a current of 100 m. amps for gas pressures ranging from 0.005 to 1.0 mm. of Hg. The frequencies used, ranged from 1 to 20 m.c./sec. and the discharge was found to have a maximum conductivity at 0.015 mm. pressure with a frequency of 15 m.c./sec. Brasefield³⁵ pursued further his measurements of conductivity. He calculated the electric force in the glow column of h.f. discharge in Hg., A and Ne. From the curves representing the voltage (required to maintain a certain current) as a function of electrode separation, he extrapolated the potential drop at the electrodes. He has published the curves representing the voltage drop at the electrodes as a function of the pressure for different frequencies ranging from 1 m.c. to 15 m.c./sec. It was found that in all the cases the electric force in the glow column was too small to impart ionisable energy to the electrons. Hiedemann³⁶ discussing the results of Brasefield has suggested that although the electric force in the glow column is small, electrons can acquire ionisable energy under conditions of simultaneous phase change and elastic collisions.

Gill and Donaldson³⁷ undertook the measurements of the striking potential V_s for mercury-free dry air. They used tubes fitted with external plate electrodes. Two experimental arrangements were tried one with the tube axis parallel to the field and the other with tube axis perpendicular to the field. They have published V_s - p curves for a wide range of frequencies between 10^6 to 10^8 cycles/sec. For frequencies higher than 4×10^6 cycles there was only one pressure for

which V_s was minimum but for frequencies below this, two minima were observed out of which one was constant while other was a function of the frequency. With the tube axis *parallel* to the electric field only one minima was observed. Gutton and Beauvais³⁸ have studied the variation of the pressures corresponding to minimum maintenance potentials with the distance between the electrodes for frequencies between 14 to 50 m.c./sec. The tubes were cylindrical and fitted with external electrodes. They have discussed the different curves so obtained. Rohde³⁹ has, by using tubes fitted with internal electrodes, obtained V_s -p and V_m -p curves for air, nitrogen and hydrogen. The frequencies used were ranging from 10^6 to 10^8 cycles/sec. Sharp minima were obtained in the curves representing V_s against p. The minimum in all the cases shifted to lower pressures for higher frequencies. For rare gases the minimum was not sharp and for neon, V_s was found to be independent of the pressure. H. Gutton⁴⁰ has published a complete work of his measurement of V_s and V_m for h.f. discharge in cylindrical tubes with internal electrodes. The gas used was hydrogen (pressures between 0.01 mm. — 0.6 mm.) The curves at lower frequencies (2.3 m.c./sec.) were found to have double minima while for higher frequency only one minimum was observed.

J. Thomson⁴¹ in 1930 developed a theory for the initiation and maintenance of the h.f. discharge with external sleeve electrodes. He has suggested that the ionisation produced by electron collisions need only be considered when dealing with h.f. discharges as the ionisation mechanism in this case need not be as efficient as in the case of d.c. discharges. Working on the basis of ionisation by electron collisions he has derived some simple relations explaining the mode of variation of the maintenance potential with the frequency of oscillation. He has found good agreement between his theoretical views and the practical results of Kirchner³⁵. The application of the tesla coil to the production of h.f. oscillations used by the author has also been discussed here. In 1934, J. Thomson⁴² undertook a systematic study of the variation of the striking potential V_s with the pressure of the gas. He has discussed the theoretical considerations about the m.f.p. of the electrons influencing the size of the tube and the distance between the electrodes to allow free motion of the electrons at the required frequencies. In order to minimise wall effects he has used internal electrodes fitted in a sphere of large diameter. The hydrogen used for the experiments was pure and free from mercury vapour. The h.f. circuit used has been very well designed and the measurements have been carried out with utmost accuracy. The range of frequency tried was 2—7 m.c./sec. In the second set of experiments he has measured V_s for different pressures using steady potential between the electrodes. His results showed that for a considerable part of the range of pressures used, V_s was a linear function of p. The gradient dV_s/dp was independent of the frequency and its value for H_2 was found to be 390 Volts/cm./mm. of Hg. for electrodes 10 cm. apart. For the V_s -p curve he found the relation: $V_s = A + Bp$, where the constant A is a function of the frequency while B is of the gas only. He has discussed these results in the light of the theory given by him. Later on,⁴³ it was observed that the sparking potential for the discharge tube depends upon the nature of the discharge which has been previously passed through it and that the passage of a h.f. discharge produces systematic variations in the "normal sparking potential."

J. Thomson⁴⁴ extended his observations on the striking potential of h.f. discharge in hydrogen to higher frequencies of the order of 10^6 cycles per sec. The tubes were fitted with internal electrodes as in previous investigations and the gas used was mercury-free. The accuracy of measurement was maintained high even at the higher frequencies and throughout the work the author has mentioned the order of accuracy and the reproducibility of the results. The V_s - p curves were found to have two minima at lower frequencies but for higher frequencies only one minima was observed. Above the critical pressure the curves were straight lines and have been represented by the relation:

$$V_s = f(\nu) + \phi(\nu) \text{ p.d.}$$

The values of $f(\nu)$ and $\phi(\nu)$ varied slowly for a wide range of frequencies, $\phi(\nu)$ was almost a constant for H_2 having a value of 18 volts/cm./m. of Hg Thomson here gives a modified theory for the h.f. discharge. In sketching this theory he has taken into account the maximum probability of ionisation with the minimum value of the field. It is suggested that the electric field strength in the region between the parallel electrodes is non-uniform, even before the discharge is struck and that the distance between the electrodes can be divided into two parts. One of these is comparatively short at high pressures and close to the electrodes. It is here that a large fall of potential occurs. The remaining space has a low uniform potential gradient. The agreement between his modified theory and his experiments was found satisfactory.

Zouckermann⁴⁵ also studied the striking potentials for h.f. discharge in (i) pure hydrogen (ii) hydrogen with traces of Hg vapour. He used cylindrical tubes with external electrodes for his discharge. At a frequency of 3×10^6 cycles/sec., both the V_s - p curves for pure H_2 and for mixture of H_2 + Hg show a minimum for $V_s = 342$ volts and 0.2 mm. pressure, and are identical for higher pressures; but at lower pressures, the curve for pure hydrogen lies above that for hydrogen with a trace of Hg vapour. For 25×10^6 cycles/sec., the V_s - p curve for hydrogen has a minimum at 0.002 mm. but with the introduction of Hg vapour this minimum moves towards lower values of V_s . Zouckermann⁴⁶ extended his observations to A and N_2 both for pure gases and with traces of Hg vapour for pressures upto 0.4 mm. of Hg. The general nature of the curves is the same as that of H_2 . It should be noted that V_s for argon was very much lowered by the presence of Hg vapour. This Zouckermann attributed to collisions of the second kind showing that the metastable atoms were taking part in the mechanism. He also investigated the effect of irradiation on V_s and found that it was independent of the wavelength as long as the light was intense. A diminution upto 15% was noted with intense light. This is suggested to be connected with photoelectric action on the glass walls. Zouckermann⁴⁷ has published all his results of the measurements of V_s for h.f. discharge in H_2 , A, and N_2 and Ne using tubes with external electrodes. The V_s - p curves have been accurately determined. The modified curves in the presence of Hg vapour have also been determined independently. The spectra of the gases concerned were studied in detail and were found to undergo great changes in the presence of Hg vapour.

The above gives an idea of the work done on the initiation and maintenance of h.f. discharges with either external or internal electrodes. There are several important points of experimental technique which have to be considered before any opinion may be formed about the theoretical value of these investigations as far as the understanding of the mechanism of the discharge is concerned. The first consideration to be made is about the form of the electrodes. Several authors mentioned above have used external electrodes, some have used plain electrodes fixed to the ends of the discharge tube while the others have used metallic rings encircling the cylindrical tube and moveable along its length. Such electrodes are much more convenient than internal ones, but for the purpose of any investigation aiming at some quantitative results internal electrodes have to be preferred. The absence of internal electrodes from the tube certainly eliminates the surface effects which have proved very troublesome in the work on D.C. discharges; but with external electrodes the glass walls take up the place of electrodes and accumulate electric charge depending on the mobilities of the ions and also the high frequency conductivity of glass reduces the electrostatic action of the applied h.f. voltage. Both these actions complicate the results to a great extent. Out of these earlier workers, the results of Kirchner's work²⁴ with internal electrodes fit in quite well in J. Thomson's theory²⁵ of the discharge as compared to others. The reason is, obviously, his use of internal electrodes.

The purity of the gas used in the discharge is also an important matter for considerations. The presence of an impurity not only causes observations to be useless with reference to the pure gas, but in many cases render them very much different from those obtained with any pure gas. Mercury vapour, unfortunately, gets an easy excess into the discharge tubes, mercury being present mostly in the system either for the measurements of vacuum or for its production. As has been very well demonstrated by Zouckermann²⁶ the presence of minute traces of mercury vapour changes completely the striking and maintenance potentials. J. Thomson²⁷ has also found that the form of the V_s - p curve for a pure gas is entirely different from the one with a trace of Hg vapour. The gases used also should be spectroscopically pure. Most of the earlier workers have not given details about the preparation and purity of the gases used. Their work thus has no quantitative importance and the values for V_s found by these authors are useless even for comparison.

The form and size of the discharge tube and the distance between the electrodes (where they are internal) also plays an important role in these measurements. The dimension of the tube should be such that the "wall effects" should be reduced to a minimum. The distance between the electrodes should be many times the amplitude of oscillation of the free electron. From theoretical considerations, J. Thomson²⁸ has shown that the distance between the electrodes should be greater than $10^6/\nu$ cm. where ν is the frequency of oscillation in cycles/sec. In many of these investigations the tubes used were narrow with considerable "wall effects", especially when external electrodes were used.

Thus considering all these points about the form of the electrodes, purity of the gas and the form of the discharge tube, most of these investigations lose all their importance as far as quantitative measure-

ments aiming at a theoretical interpretation are concerned. The most outstanding work in this direction is that of J. Thomson^{42, 44} who has taken all these matters into consideration. This is the latent reason for his results being perfectly reproducible and his V_s - p curves fairly fitting in the theoretical picture drawn by him. Zouckermann's work⁴⁷ is also important as far as the work with external electrodes is concerned. His observations on the influence of the presence of traces of mercury vapour on the striking potentials are very interesting.

In the end a word should be added regarding the methods used in these investigations for the measurement of the h.f. alternating potentials. Workers from Gutton school have used electrometer for the measurement of h.f. voltages. The use of the electrometer involves delicate technique. The latest electrometer used by Zouckermann⁴⁷ is a modified form of the one originally used by Gutton. The precision in the measurement of V_s has not been mentioned by these workers. Kirchner^{35, 36} and others have used an ingenious method for this purpose. The h.f. voltage was measured from the deviation of a beam of electron passing between two electrodes to which this voltage was applied. Here also the precision of measurement has not been mentioned, but with this method, it is not expected to be high. Townsend school^{18, 32, 37} and Thomson^{42, 44} have used the "heater and thermocouple" method for the measurement of V_s . The thermocouple instrument is placed near the potential node between two approximately equal condensers. The precision of measurements depends much on the precision in the measurement of these capacities. Thomson got a precision of 3 per cent in the absolute values of V_s and relative values were correct within 1 per cent.

The form of the V_s - p curve found by most of the workers is that of a Paschen curve. The curves are found almost linear at higher frequencies. These curves can be represented by $V_s = A + Bp$, where the constant A is a function of the purity of gas and also of the frequency of excitation. The double minima (in these curves) by Gill and Donaldson³⁷ and C. & H. Gutton³⁰ seem to be real and have been obtained by J. Thomson⁴¹ also.

(ii) *Energy of the Electrons*

Some attempts have been made to determine the mean energy of the electrons in h.f. discharge. Brasfield,^{34, 35} first of all, attempted to calculate the maximum possible velocity of the electrons from elementary considerations. He found the electric force in the glow column of the h.f. discharge by measuring the potentials required to maintain a certain current for two values of the distance between the electrodes *i.e.*, for two different lengths of the glow. (Keeping other parameters constant). He assumed that the potential drop at the electrodes, being independent of the distance between them, was constant as long as the current and other parameters were constant. It was also assumed that the electric force was constant throughout the column. Thus from the potential gradient he was able to calculate the electric force in the glow column. The variation of the potential drop at the electrodes and the electric force in the glow column with variation in pressure ranging from 0.01 to 0.1 m.m. of Hg was investigated for He and Ne. These

observations were made for different frequencies between 1.2 m.c./sec. to 22.5 m.c./sec. The values of the electric force in general were found to be round about 2 volts/cm., which was too small for producing ionisation by electron collision. Hiedemann⁴⁸ has worked out some possibilities of electrons acquiring ionising velocities under the conditions of simultaneous phase change and elastic collision. He has criticised Brasefield's assumption about the constancy of the electric force in the glow column.

Brasefield⁴⁸ and Matuyama⁴⁹ also tried to determine the mean energy of the electrons in the glow column of the h.f. discharge by an indirect method. Brasefield's⁴⁸ method was to find the mean energy of the electrons from the measurement of the ratio of the intensities of two neighbouring lines in the secondary spectrum of hydrogen emitted by h.f. discharge through hydrogen. The curve representing this ratio as a function of the uniform energy of the exciting electrons was determined from the results of separate experiments, where electrons with given known energy were employed to excite the spectrum. Using this method Brasefield has measured the mean energy of the electrons in the uniform glow of h.f. discharge through hydrogen in cylindrical tubes with external electrodes. The experiments were tried for the values of frequencies between 3 m.c. to 15 m.c./sec. and for gas pressures ranging from 0.01 mm. to 0.06 mm. of Hg. The voltage was varied between 300-2000. The values found for the electron energies in different cases are between 20 and 28 e.v. Brasefield has tried to give a simple picture of the electrons oscillating in the h.f. field and has explained the variations of the energy of the electrons by the help of this picture. He has found that,

- (i) At all frequencies used, the electron velocity increases with increase in voltage.
- (ii) At a given voltage between the electrodes, the electron velocity, in general, decreases with an increase in frequency.
- (iii) The electron velocity increases with decreasing pressures.

There have been some attempts to directly determine the energy of the electrons in the h.f. discharge by means of the *Probe method*. Banerji and Ganguli⁵⁰ were the first to apply this method to the study of the space potential distribution, ionic concentrations and average electron velocities in h.f. discharge through air and oxygen. The cylindrical tubes used were fitted with external sleeve electrodes. The h.f. discharge was excited at a frequency of 1.2 m.c./sec. for gas pressures round about 0.1 mm. of Hg. The authors have used an iron bobbin as the auxiliary probe for referring the probe potential. The auxiliary probe was placed away from the main discharge to avoid disturbance and the probe circuit used was the usual one generally used in the study of d.c. discharges. They have found that the potential distribution is symmetrical about the middle point of the discharge, both the electrodes acting as though they were cathodes. The value of the potential at any place was found to depend on the gas pressure. The space potential-distance curve (distance from one of the electrodes) shows a maximum in the middle of the glow column and there are two minima, one near

each electrode. The concentration of the electrons is highest at the middle point of the glow column. The electron concentrations found are rather low, *i.e.*, round about $5 \times 10^8/\text{c.c.}$

In their second investigation with the same experimental arrangement Banerji and Ganguli⁵¹ have measured the space potentials, ionic concentrations and mean energy of the electrons in striated, non-striated and plasmoidal form of the h.f. discharge. It is observed that for non-striated discharge the concentration of electrons falls with the rise of space potential. In striated discharge the space potential as well as the concentration of electrons fall in the dark spaces. The plasmoidal discharge is characterised by the abnormally high values of the space potential. The values of the energy of the electrons in general are found to be round about 0.1 e. volt. and of the concentration of electrons round about $10^{11}/\text{c.c.}$ In order to verify the correctness of the *Probe method* in the modified form as used by these authors, they measured the space potentials in a conical tube. It was observed that as found in the experiments with cylindrical tubes at the middle of the tube, the potential was higher than that near the electrodes. They expected that near the electrode on the wider side of the tube the potential should be higher than that at the constricted end—which was found correct. This the authors declare to be a good confirmation of the correctness of the *probe method* in the modified form as applied to h.f. discharges.

Beck⁵² attempted a comparative study of the positive column of the d.c. discharge and the uniform glow column of the h.f. discharge in mercury vapour. The discharge tube was provided with an incandescent cathode and a disc anode for exciting d.c. discharge. Two external sleeve electrodes were used to excite the h.f. discharge. The tube was provided with two cylindrical probes (0.2 mm. diameter) and an auxiliary probe in the form of a spiral of nickel ribbon. The probe potential was always referred to this auxiliary probe which was mounted in the centre of the discharge tube (*main discharge*). The surface area of the auxiliary probe was kept much greater as compared to that of the probe. Thus the d.c. discharge as well as the h.f. discharge could be excited in the same tube under absolutely identical conditions. The results of the probe study of the two discharges revealed that the mean electron energies, electronic concentrations and even the space potentials agreed well in the two cases. The energy of the electrons was of the order of 0.7 volts and concentration round about $10^{12}/\text{cc.}$ Beck aided his observations by spectroscopic and absorption measurement in the two discharges excited in identical conditions, and found a complete analogy between the two uniform glow columns. He has criticised the experimental arrangement of Banerjee and Ganguli⁵⁰ and suggested improvements in the technique of probe measurements in h.f. discharges.

The small amount of work done on a very vital but complicated aspect of the h.f. discharge does not allow to pass any positive remarks on these investigations. Brasfield's spectral method⁴⁸ for the measurements of the mean energy of the electrons has some serious drawbacks. This work along with the investigations of Banerji and Ganguli^{50, 51} and of Beck⁵² has been discussed already in detail in a previous paper.⁵³ It is worth mentioning here that if with proper modifications *probe*

method can be applied to h.f. discharges it will take us a long way in understanding the ionisation mechanism of the h.f. discharge. The study of the variation of the mean energy of the electrons with the discharge parameters is also equally important and can be accomplished with proper technique of "*probe measurements*."

(iii) *Miscellaneous*

The other investigations on the striations and appearance of the h.f. discharge are all qualitative. Richard⁴⁴ has published the photographs of the double striations observed frequently in h.f. discharges. McCullum and Perry⁴⁵ have measured the fall of potential per striation in discharges with external as well as internal electrodes. Wood has studied the plasmoids formed at lower pressures. Chatterji and Ghosh⁴⁶ among others have recorded the different colours from the discharge under varied experimental conditions and in many gases. Gutton and Chenot^{48, 49, 50} have given the theory for the ionised centres (plasmoids) along the column of the h.f. discharge on the basis of stationary waves set up in the discharge and verified it experimentally. Brandt⁵¹ has investigated the change in the appearance of the h.f. glow discharge at frequencies from 50 to 10⁹ cycles by stroboscopic arrangement.

The h.f. discharge with external electrodes has been found a good source of excitation of spectra. Many interesting changes have been found to occur in the spectra with change of pressure and frequency of excitation. These changes are specially very much marked in mixtures of gases.^{63, 64, 65} Lot of speculation has been done in explaining the nature of these changes and their relation with the electrical discharge characteristics responsible for this selective excitation.

On the theoretical side, as yet no complete work is available. As remarked by Loeb "the theory given by J. Thomson supported by his own systematic experimental study is in general plausible and probably correct." Townsend's³⁹ theory of the glow column looks simple, but probably some more complicated processes occurring in the discharge still remain to be explained.

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DIRECT METHOD OF MEASURING RELATIVE SPECTRAL INTENSITIES: ITS TECHNIQUE AND USE IN LINE AND BAND SPECTRA

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I. INTRODUCTION

VARIOUS methods of objectively measuring spectral intensity distributions have been developed out of which the method of photographic photometry stands out most prominently, being convenient as well as accurate. Its main advantages over other methods are that it is a detector or receiver of the integrating type, thus being pre-eminently suitable for the very low intensities encountered in this type of work, the response to which can be built up to a measurable value by sufficiently long exposures, and that it records the intensities in all the wave-lengths simultaneously, thus causing a much lower average error by distributing the disturbances in the radiating source equally throughout the spectrum. The main objections against it on the other hand, are due to its stimulus-response relationship being mathematically undefinable and its selectivity, *i.e.*, unequal response to equal amounts of flux in different wave-lengths. Methods have been devised to get over these objections, *e.g.*, the Null method of Jones¹ in which the photographic plate is used merely as a judge of equal intensities, and the calibrated-step-slit method of Johnson and Tawde² and others³ in which the stimulus-response curve of the material is determined on every plate at any required wave-length and the varying factor of proportionality accounted for. This is the method in use at these Laboratories for the investigation of various problems, and it was with the ultimate aim of testing this method in detail by comparison with direct measurements of spectral intensity distributions that we have been led to set up the present arrangement, which, though not so versatile and flexible as the Photographic method, can serve as an alternative method in a limited range at least. The present work, however, has been mainly experimental and limited to putting the apparatus in as sensitive and stable a form as possible, and as a preliminary application of it, certain intensity distributions have been measured with it.

II. EXPERIMENTAL ARRANGEMENT

The spectral resolving apparatus was a Fuess constant deviation glass monochromator, with an extension tube containing a focussing lens mounted on the exit-slit. The detector, a Weston Photronic cell type 1, was mounted directly on this tube and the image of the exit-slit focussed on to its light-sensitive surface. The whole optical path

from entry-slit to photocell was totally enclosed. As some stray radiation was found in the instrument itself at the end of its range, *viz.*, 7500 to 7000 A.U., this portion was not investigated. The other limit was fixed at 5000 A.U., as the radiant flux emitted by the incandescent lamps used and the sensitivity of the photocell, both decrease in this spectral region, whereas the dispersion of the monochromator increases causing a decrease in the radiation reaching the cell, all these three factors causing the cell-current to be too feeble even for the sensitive amplifier. This primary photocell was connected to a Pye Granta galvanometer, the primary galvanometer. The minute deflections of this galvanometer were amplified by a photo-electric relay of the Barnes-Matossi type with certain improvements. As described by Barnes and Matossi⁴, the relay consists of (Fig. 1a) an intense light-source S, the exciter, of which the image is focussed on the mirror M of the primary galvanometer G by a condensing lens C. Just in front of this lens is a square aperture A which is thus uniformly filled

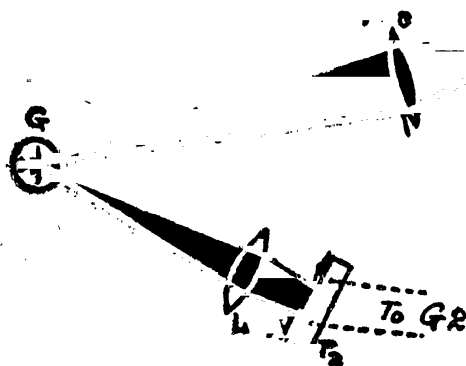


FIG. 1(a)



FIG. 1(b)

(Dotted square—illuminated image of aperture A)

with light and its image is focussed on a rectifier-type photocell, having another aperture A¹, by the mirror M and the focussing lens L. This aperture A¹ is also square and of a size somewhat smaller than the image A, which image is made to fall on it as in Fig. 1b, so that a deflection of the primary galvanometer G causes a proportionate variation in the area of the light-spot on the photocell P2, the secondary photocell. This being connected to the secondary galvanometer G2 (not shown) and the light-spot being sufficiently intense, a small movement of the light-spot due to a small deflection of the primary galvanometer would cause a large deflection of the secondary galvanometer G2, thus constituting an amplifier. The amplification of this would be constant, if (i) the intensity of the exciter does not fluctuate; (ii) the aperture A is filled uniformly with light over its whole area; (iii) the sensitivity of the photocell does not vary with its irradiation, and (iv) the sensitivity of the photocell does not vary from place to place over its area. Condition (i) can be satisfied nearly rigorously by working the exciter lamp on fully charged storage cells; condition (ii) by careful adjustment of the aperture and the lens C; condition (iii) by considerations given further on in § IV, 1, but condition (iv) depends on the photocell itself.

It has been found by us in previous work and has also been mentioned by Larsen and Shenk¹ that the sensitivity of the photronic cell varies from place to place on its surface due to uncontrollable variations in manufacture, so that condition (iii) cannot be fulfilled at least in the case of this make of rectifier-type cell. To get over this difficulty the arrangement was changed making this condition superfluous. The aperture A^1 over which the movement of the light-spot takes place is not kept in direct contact with the photocell P_2 , but is kept just in front of a convex lens L^1 (Fig. 2) which focusses the image of the illuminated mirror M on the photocell surface. The movement of the

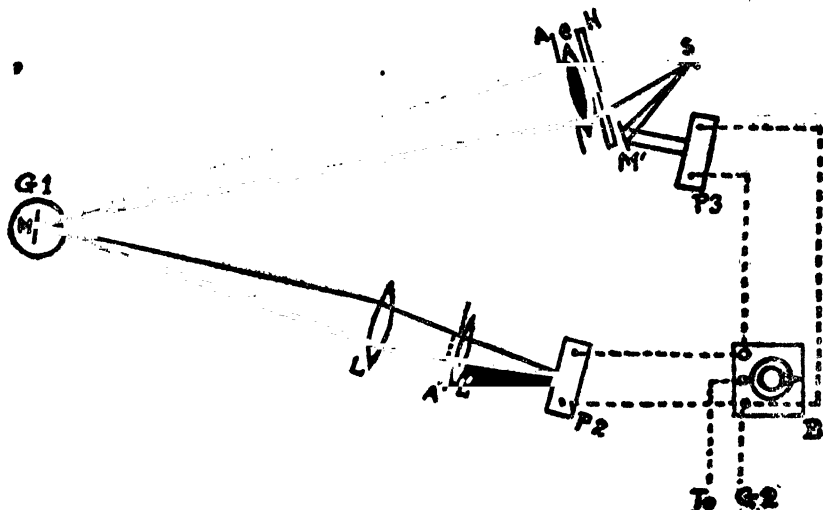


FIG. 2

light-spot due to that of the mirror causes merely a variation in the intensity of the mirror image which shows a slight obliquity, but does not shift over the photocell surface. An improvement was also made to compensate for any momentary fluctuations in the intensity of the exciter lamp. Another Photronic cell type 1, P_3 , (Fig. 2) was irradiated by the exciter through a small mirror M^1 this compensating cell being enclosed in a box with a small aperture in front of it. By tilting the mirror M^1 suitably, the light falling on it is made equal to that on the secondary photocell P_2 to which it is connected in parallel-opposition, the equality of illumination being indicated by the secondary galvanometer coming to and remaining at its null position with the primary galvanometer carrying no current. This device also allows the light-spot being operated on the central portion of the aperture A^1 instead of on one side, giving better optical definition without subjecting the secondary galvanometer to unduly heavy deflections. The clue for this was taken from Gerschmowitz and Wilson² but the cells are not connected in series-opposition as shown by them, but in parallel-opposition. The reason is that these photocells also act as rectifiers, and if joined in series-opposition, either cell has to force its current through the other against the rectifying action of the latter to complete the circuit with the galvanometer, the sensitivity of the relay being unduly lowered thus. This objection does not arise in the case of connection

in parallel-opposition, each cell sending current to the galvanometer opposite to, but independent of the other.

In the beginning much difficulty was experienced due to the zero of the secondary galvanometer drifting heavily consequent upon a slight drift in the primary galvanometer. The drift did not reverse in direction on reversal of the primary galvanometer photocell connection and hence thermal e.m.f.s were suspected in the galvanometer itself. At last, it was found that the seat of these e.m.f.s was the bimetallic junction of the phosphor-bronze suspension and the coil of copper wire. The junction being situated just below the mirror, the focussed light of the 750 watt exciter filament fell on it also, and caused heating in spite of a 4 cm. thick water-cell put in the path of the beam of light to absorb the heat. The drift was reduced at once in a very striking manner merely by putting a cardboard screen in front of the galvanometer in such a way that no light fell on the coil-suspension junction. The effect was further reduced by interposing a 2 mm. thick heat-absorbing glass, such as is used in epidiascopes and cine-projectors, before the exciter lamp; the glass cut off strongly the hot infra-red rays allowing almost all the visible to pass through, thus giving great stability to the system without lowering the sensitivity much. When a more sensitive Leeds and Northrup galvanometer having an all-copper electrical system was acquired at a later stage and tried out in place of the Pye galvanometer, no appreciable drift was found even without the cardboard screen and the heat-absorbing glass, thus showing that the effect was in the bimetallic junction.

Another source of trouble was the effect on the system caused by merely touching the wooden table on which most of the apparatus, except the amplifier, were lying. Whenever the table had to be touched for adjusting the apparatus, a deflection of several centimeters, sometimes even more than full-scale, would take place. The effect was present, though less markedly, even with the person touching seated on a wooden stool with his feet off the ground. This trouble was finally traced to the minute leakage of current from parts of the apparatus—such as the lamp for illuminating the scale of the secondary galvanometer and the leads of this lamp—connected to the 220 volts mains. It was almost completely eliminated by covering most of the table-top with thin metal sheet and earthing the same. To prevent spurious p.d.'s developing in the apparatus, the case-connected terminal of the primary galvanometer and the negative terminal of the primary photocell were also earthed.

Details of the arrangement as used for this work are as follows (Fig. 2) :

The light from the exciter lamp S (Bell and Howell Filmo 16 mm. cine-projection lamp, 110 volt, 750 Watt, biplane filament of area about 1 sq. cm.) is focussed through the heat-absorbing glass H by a condenser C (Focal Length 5 cm., diameter 5 cm.) on the mirror M (concave, diameter 10 mm.) of the Pye Granta galvanometer G1 (resistance 50 ohms, dead-beat, sensitivity 2.5×10^{-8} amperes per milliradian, 14 seconds period). An image of the aperture A' (3 cm. square) just in front of C is formed by the mirror M and the lens L (convex, f.l. 30 cm., diameter 6 cm.) on the second aperture A' (2 cm. high, 1 cm. broad). The lens L' (convex, f.l. 20 cm., diameter 5 cm.) immediately behind this aperture forms an image of the mirror M through L and A'

on to the Weston Photronic type 1 cell P2, of which the current is led to the secondary galvanometer G2 (Moll Micro, resistance 20 ohms critical damping resistance 55 ohms, sensitivity 2.5×10^{-8} amperes per milliradian, period 0.2 sec.), through an Ayrton-Mather universal shunt-box. A small mirror M' reflects some light from S on to the compensating photocell P3 (same make and type as P2) which is connected in parallel-opposition to P2.

The distances between the various components of the relay were as follows :

SC or SA, 13 cm. ; AM, 45 cm. ; ML, 36 cm. ; LA' or LL', 63 cm. ; L' P2, 19 cm. ; secondary galvanometer scale distance, 1.5 m.

The amplification-factor, *i.e.*, the ratio of the scale-deflection of G2 to the movement of the light-spot causing it, was 500, with the exciter lamp worked at 100 volts—rather below its rating—to prolong its life. The current-sensitivity of the whole system worked out at 8×10^{-11} ampere per milliradian.

A more sensitive galvanometer (Leeds and Northrup, resistance, 13 ohms, critical damping resistance 45 ohms, sensitivity 8×10^{-8} ampere per milliradian, period 5 sec.) and a Photronic cell type 2—of higher sensitivity than type 1—were acquired at a later stage in the progress of the work, but these were not used much, except for purposes of comparison. With the Leeds and Northrup galvanometer in place of the Moll Micro as secondary galvanometer with the Pye Granta as primary, amplification-factors upto 1700 could be had, but this extra sensitivity could not be exploited due to the lack of making the system vibration-free. (Please refer also § IV, 6.)

III. EXPERIMENTAL TECHNIQUE

1. *System of taking readings* :—A definite and uniform system was followed in taking all the readings in order to reduce to a minimum the errors due to slight drift and erratic shifts in the sensitive amplifying apparatus. Readings with reversals of the connection between the primary photocell and galvanometer were not feasible as most of the drift was due to thermo-electric effects in the galvanometer itself, and as the case-connected terminal of the galvanometer and the negative terminal of the photocell were earthed. Therefore the monochromator was provided with a simple shutter between the exit-slit and photocell, and the null position of the system was read between deflections so that the actual rate of drift could be taken into account from the increase or decrease of the null readings. The deflection and null readings were taken alternately at intervals of 30 seconds, during which the Pye galvanometer could reach its steady position completely. Due to this regularity, the null position of the system at the time of taking a deflection reading was the mean of the null readings taken immediately before and after that deflection reading, and vice-versa, assuring a steady rate of drift. The difference between a reading of either type and the mean of the readings of the other type taken immediately before and after it, was taken as the actual deflection. The wavelength-setting of the monochromator was changed between the deflection readings, *i.e.* with the shutter closed, usually 2 or 3 values of the deflection being taken at each wavelength-setting. This procedure was followed at each

wavelength-setting, first from the highest setting to the lowest and then again at the same wavelength-intervals—but in the reverse order—from the lowest to the highest, so that any error due to a gradual decrease in exciter lamp intensity consequent upon the discharging of the storage cells, would be minimized. However, this effect was found to be generally absent or of a very low order, as care was taken to keep the batteries fully charged always. During all the settings with increasing wave-lengths, the wavelength-drum was always rotated to a value somewhat higher than the required one and then carefully set back to that value, so as to avoid errors due to backlash in the drum-prism coupling, the wavelength calibration of the monochromator having been done at settings with wave-lengths decreasing. This method of taking two sets of readings was used in preference to regulating the p.d., across the exciter lamp, because the change in amplification with change in voltage is so great that the slightest inaccuracy in setting the voltmeter would cause a much greater error by changing the amplification.

Four or five such sets were taken for each light source and the final mean values of the deflection used for the purposes of calculation. Due to the difficulties of voltage regulation mentioned above and the consequent variation in the amplification factor used for different sets, it used to happen that the readings for the same wave-length in different sets did not appear consistent enough. Even then each set would be found to have all readings almost consistently larger or consistently smaller than those in the other sets, thus indicating that respectively a larger or smaller amplification factor was used for that set. To bring all the sets to the same scale so as to be able to estimate the probable error of each reading, the ratio of each reading to the corresponding mean was taken. The ratios in each set would be found to be consistently greater or less than unity and to fluctuate closely round a mean value. All the readings in each set were then divided by the corresponding ratios, to give readings all on the same scale.

The ratios were taken only when it was necessary to estimate the probable error of single deflection readings, for comparison with other such readings, as in the case of the 10 and 11.5 amp. calibrations of the monochromator with Photronic cell type 1. For the remaining cases, the means or sometimes only the sums of the readings were directly used in the calculations.

2. *The calibration of the arrangement* :—As the receiver was selective, it was necessary to know the response-wavelength relationship of the arrangement and it was, therefore, calibrated by means of a standard Kipp and Zonen tungsten-band lamp with known flux-distributions with various currents through it. The main calibration, with the Photronic cell type 1, was done at a current of 11.5 amps. in the standard lamp corresponding to a true temperature of 2420° K at the centre of its band. Another calibration was done later with the more sensitive Photronic cell type 2 as receiver at 10 amps. current in the standard lamp.

As the calibration is relative, the calibration curve shows relatively the different amounts of radiation required to produce unit response of the apparatus at the corresponding different wave-lengths. The ordinates of this curve are called the *calibration-numbers*. These make

it possible to compare unknown amounts of radiation relatively among themselves by multiplying the responses produced by them with the appropriate calibration-numbers. The measurements of the unknown radiations being carried out under the same conditions as those governing the calibration, and absolute values being not required, the variable factors like the spectral sensitivity of the photocell, the selective transmission losses in the dispersing instrument and the dispersion of the same are thus automatically taken into account, as these factors are the same for both, the standard as well as the unknown radiators. However, the dispersion of the instrument has to be taken into account when measuring discontinuous radiation of discrete wave-lengths (line spectra) if the calibration has been carried out with a source emitting continuous radiation.

Thus, the *calibration-number* n is the ratio of the known radiant flux emitted by the standard lamp at the wave-length λ , per unit wave-length interval, to the deflection d at that wave-length, which d depends upon the interval $d\lambda$ in which the flux is emitted; thus $n=F/d$. This interval $d\lambda$ is the same for any other source of continuous radiation used with the same monochromator with the same slit-widths, and for such a source it is taken into account by the calibration-number itself. But if line intensities are being measured the values of the deflections have first to be reduced to values corresponding to a "normal" spectrum, i.e., a spectrum in which the distances are directly proportional to the wave-lengths. This is accomplished by multiplying each d by the corresponding slope $d\theta/d\lambda$ of the dispersion curve, where θ is the angle of rotation of the prism. As only the slope is required, the absolute values of θ need not be known. Thus, the "line" calibration numbers are n' equal to $F/(d \cdot d\theta/d\lambda) = F \cdot d\lambda/d \cdot d\theta$. Relatively this is the same as $F \cdot d\lambda/d \cdot d\theta$, the angle subtended at the axis of rotation of the prism, by the exit slit-width, being independent of the wave-length. This quantity is the ratio to the deflection d , of the flux totally emitted by the standard lamp in the wave-length-interval $d\lambda$, and not per unit wave-length interval as before.

The calibrated results (λ against n and n') are given below in Tables 1 and 2 for both types of Photronic cells, and the curves of the same are plotted in Figures 3 and 4.

TABLE No. 1

*Calibration of Monochromator with
Photronic Cell Type 1*

	n	n'
7000	129.0	200.0
6750	87.0	157.0
6500	50.4	101.0
6250	37.8	86.9
6000	36.0	97.1
5750	45.0	144.0
5500	58.8	223.0
5250	84.4	380.0
5000	119.8	629.0

TABLE No. 2

*Calibration of Monochromator with
Photronic Cell Type 2*

	n	n'
7000	74.0	115.0
6750	34.0	61.2
6500	20.9	41.8
6250	16.5	38.0
6000	16.0	43.2
5750	17.2	51.9
5500	21.4	81.3
5250	27.6	124.0
5000	36.2	185.0

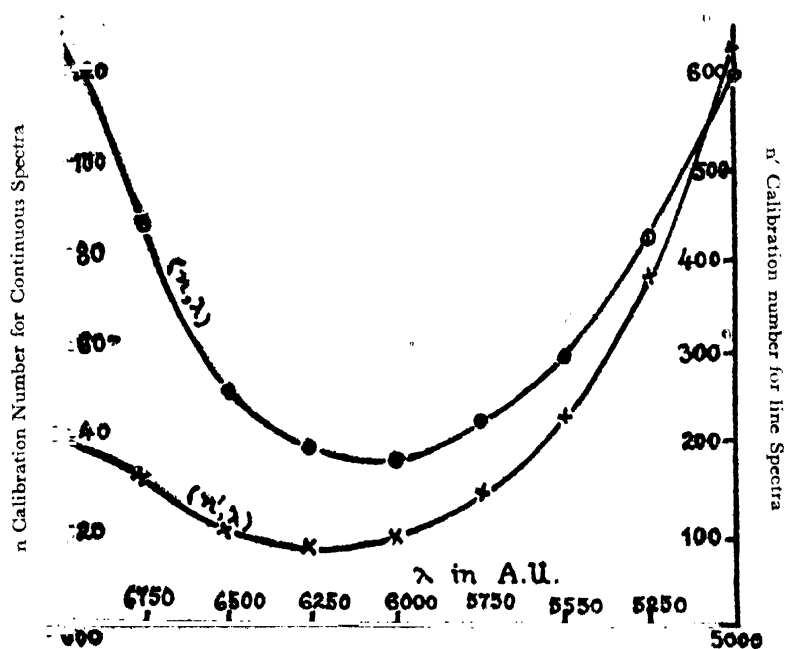


FIG. 3

Calibration of Monochromator with Photronic Cell Type 2

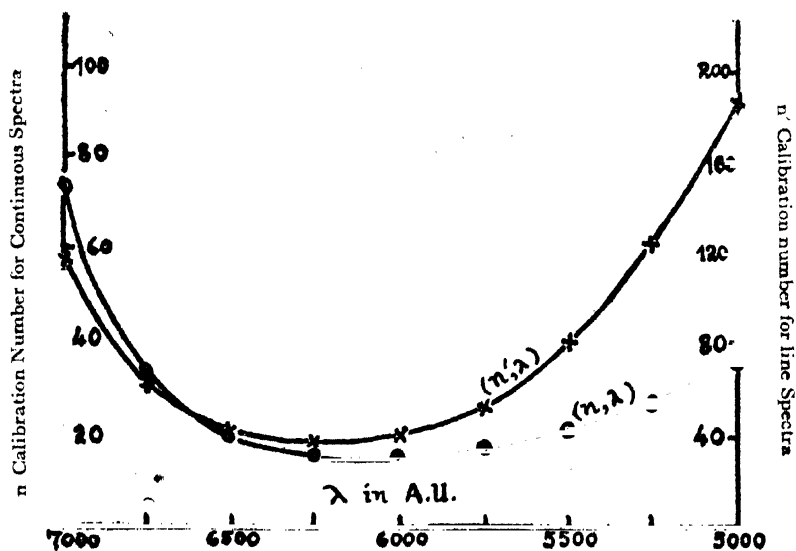


FIG. 4

Calibration of Monochromator with Photronic Cell Type 2

IV. THE PRECISION OF MEASUREMENTS

1. *The "Linearity" tests* :—For a rather complicated arrangement like the present one, it is necessary to know whether and to what extent, the stimulus-response relationship preserves proportionality within the range of values used. This was particularly so because of the tendency of the Photronic cell output to saturate with higher values of irradiation. This cell, is of the rectifier type, which in general consists of a metal disc supporting a thin film of semiconductor, which in turn supports a transparent film of a good conductor. In the Photronic cell, the selenium layer on a supporting disc of metal is the semiconductor and the film of Gold or Platinum sputtered on to it, the good conductor. A barrier-layer is postulated to be formed at the surface of contact of the selenium layer and the metal film, and this type of cell is therefore also known as barrier-layer photocell. In the film of metal, there is an abundance of free electrons as compared to the selenium and the light incident on the barrier-layer causes an escape of the free electrons across the barrier-layer and the inter-crystalline spaces of the selenium to the metal supporting disc, with the result that the supporting base acts as the positive terminal and the metal film on top as the negative. These cells also exhibit a remarkably asymmetric conductivity due to reasons similar to the above, and are therefore widely used in power engineering for rectification of alternating currents. Hence the designation, rectifier-type.

The cell generates a current directly proportional to the incident radiant flux, but its current output may not be so proportional if the external resistance is high. This is because the cell has an internal leakage path which acts as a resistance in parallel with the external circuit. Moreover, this internal resistance varies with the irradiation, from a value of about 8000 ohms at no irradiation to about 1000 ohms at 200 foot-candles. Thus there is a variable shunting effect on the currents generated by the cell, which causes saturation of the current output at higher values of irradiation. The shunting effect decreases as the external resistance is lowered and theoretically the cell should be worked with zero external resistance to obtain strictly linear response. However, practical linearity can be obtained with external resistances as follows :—Upto 5 foot-candles, 1000 ohms ; upto 10 f.c., 250 ohms ; upto 100 f.c. 100 ohms ; upto 250 f.c., 20 ohms for the type 1 cell, and somewhat lower for type 2. This peculiar property of the cell creates a problem in the choice of the galvanometer to be used with it. Thus, to obtain linear working of the cell, a galvanometer of low internal resistance has to be used, but this usually has a correspondingly lower critical damping resistance, whereas the cell has an internal resistance of some thousands ohms. This causes the galvanometer to be badly underdamped and some sensitivity has to be necessarily sacrificed in damping the galvanometer to the critical value. It seems from our experience that a proper galvanometer for use with the Photronic cell is one with a low resistance (depending on the maximum illumination expected), a critical damping resistance of 1000 ohms or more, and a short period of oscillation.

As all the galvanometers used by us in our work had low resistances, over-all linearity of the whole system was expected. This was tested also by converting the apparatus into a densitometer and measuring the known densities of a Kodak standard step-wedge. It was found from

this that linearity, i.e., constant proportionality between stimulus and response, is obeyed within at least $\pm 1\%$ upto 200 scale-divisions of the secondary galvanometer, which is more than the maximum value of deflection recorded by us in the above work.

2. *The reproducibility of results* :—The values of the deflection obtained continuously one after the other at any one wavelength-setting over long periods of time, at 30 seconds intervals between null and deflection readings as usual, were found to agree among themselves. This was shown by the agreement, within limits of their probable errors, among the means of each of the three groups into which the set was subdivided.

The main test of the apparatus lay in how far the various sets of wavelength-deflection results obtained from readings taken at widely differing times and with readjustments of parts of the apparatus in-between, agreed among themselves. As mentioned before, it was not found possible to adjust the apparatus to exactly the same sensitivity everytime and so, single readings taken at widely different times were useless for purposes of comparison; only complete sets of readings could be relatively compared. This was done by bringing all the readings to the same scale as in § III, 1 above. By this method it was found that in the earlier stages, the deflections in any one set of deflection-wavelength results were probably in error by $\pm 6\%$ and 8 or 9 such sets had to be taken to lower the probable error of the mean to $\pm 2\%$. After improvements of the arrangement, when a calibration was done with 11.5 amps. current in the standard lamp, it was found that the p.e. for a single reading was $\pm 4\%$ and the same accuracy as before ($\pm 2\%$) could be had by taking only 4 or 5 sets of readings. This is the p.e. of the final values of deflection used for purposes of calculation in this work. With the Photronic cell type 2 and the Leeds and Northrup galvanometer, the error was only $\pm \frac{1}{2}\%$ in the final mean values.

The p.e. in the values of the flux, obtained by multiplying the deflections with the corresponding calibration-numbers, are twice the p.e.s stated above, because the calibration-number also has the same percentage uncertainty as the deflection. Thus the values of the flux, used in this work, are probably uncertain by $\pm 4\%$. Those measured later with the more sensitive galvanometer and photocell are probably in error by $\pm 1\%$. However, the p.e.s in the temperatures of the sources emitting continuous radiation calculated from their flux distributions measured by this apparatus come out to be about $\pm 0.2\%$ for the first arrangement used in this work and $\pm 0.1\%$ for the second (Please see also § V, 2).

3. *The calibrations at 10 and 11.5 amps* :—The spectral flux distribution of the calibrating standard lamp being different at different currents, the calibrations of the apparatus at two different values of the current can serve as an independent check on the consistency. The two values used in the present work were 10 and 11.5 amps and each calibration-number had a p.e. of $\pm 2\%$, so that their ratio is expected to have a probable variation of $\pm 4\%$. The actual variation found was $\pm 3\%$ indicating that the agreement is good.

4. *The G. E. C. Standard lamp* :—Another independent verification is obtained from the estimations of the filament temperature of a special G.E.C. standard lamp used to provide calibration density marks for photographic photometry by the method of Johnson and Tawde.⁸ The measurements of the relative flux distribution of the lamp were carried out with this apparatus using both the types of Photronic cells, which have different spectral sensitivities. The distributions and temperatures come out to be equal within limits of their probable errors.

5. *The slit-widths* :—The entry-slit width was kept uniformly at 0.1 mm. during most the work and 0.05 mm. during the latter. No corrections for overlapping in the spectrum due to finite slit-width have been applied, because care has been taken to keep the slit-width the same throughout and sufficiently narrow so as not to cause an error much in excess of the probable errors of the readings. The correction for dispersion has already been discussed in § III, 2.

6. *Increase in efficiency due to amplification* :—Barnes and Matossi⁴ describe a method of judging the increase in efficiency of the primary galvanometer due to amplification, taking into account the maximum efficiency of the galvanometer possible without amplification. The treatment given here differs somewhat from that by the above-mentioned authors, but the conclusions are the same.

Mere statement of the factor of linear amplification V , the ratio of the linear deflection of the amplified system to the linear deflection of the light image, cannot indicate the efficiency of the system, as this can be increased to any extent, without real advantage accruing, by using a more sensitive galvanometer or photocell in the amplifier. A limit is set to such an increase by the disturbances of the mirror due to mechanical vibrations, and when these are eliminated due to Brownian motions in the higher limits of sensitivity. However, it is not generally possible to realise this limit merely by the primary galvanometer with its lamp and scale, and there amplification comes in really useful. This is because the maximum distance of the scale from the galvanometer is determined by the diameter of the mirror. As a general rule⁴ the maximum distance from a mirror of diameter d mm. at which a scale can be read correct to 0.1 mm. is $1000 d$ mm. or d metres.

If now w radians be the root-mean-square angular fluctuation of the mirror of the primary galvanometer due to unavoidable disturbances, the corresponding fluctuation on the scale at the maximum possible distance is $w \cdot D1$ metres or $1000 w \cdot D1$ mm., where $D1$ is the diameter of the mirror in mm. and also the scale distance in metres according to the rule above. If this ($1000 w \cdot D1$) be less than 0.1 mm. which we take as the uncertainty of reading the scale, the deflections can be read correct to 0.1 mm. in spite of the fluctuation. The real help rendered by the amplifier then lies in amplifying just to such an extent that the fluctuation is also just amplified to 0.1 mm. and the highest sensitivity possible in the circumstances attained without raising the fluctuation unduly. The increase in efficiency, L , may thus be taken as the ratio $0.1 : 1000 w \cdot D1$. The value of w itself can be determined experimentally by finding the r.m.s. fluctuation of the scale readings of the secondary galvanometer. If this be f mm. and

the distance between the primary galvanometer mirror and the aperture over which the light-spot moves be d_1 metres, $f=1000 \cdot V \cdot w \cdot d_1$, so that $w=f/(1000 \cdot V \cdot d_1)$ and $L=0.1/(1000 \cdot w \cdot D_1)=0.1 \cdot V \cdot d_1/(f \cdot D_1)$.

For the first amplifier with the Pye as primary galvanometer $V=500$, $d_1=1$ metre, $D_1=10$ metres and $f=0.4$ mm., and so, L comes out to be 12.5.

For the later system with the Leeds and Northrup galvanometer as primary, $V=80$, $d_1=1$ metre, $D_1=12$ metres and $f=0.3$ mm., and thus $L=2.2$.

It is rather surprising that the amplifier, thus, increases the efficiency of the Pye galvanometer more than that of the L. & N. However, this is because, (1) the L & N has a larger mirror and can be used more efficiently than the Pye, *without amplifier*, and (2) its lighter suspended system is mechanically more sensitive to vibrations than the bulky Pye Granta system though the Pye used to rest directly on a marble-topped table, whereas the L & N was on a wall-bracket.

It may be noted here that even if larger amplification factors had been used, L would have remained the same with the primary galvanometers in their present mountings, because both the amplification-factor V and the uncertainty f would have increased in the same proportion. The efficiency can be really increased further only if the unsteadiness of the primary galvanometer is decreased by mounting it on some form of a vibration-free support. Here again the efficiency would reach a higher limit at Brownian motions. In the same way, though Barnes and Matossi using very sensitive galvanometers could attain linear amplification-factors upto 1,25,000, and though their primary galvanometer was mounted on a Mueller-Strong type support, the disturbances due to Brownian motions used to cause r.m.s. fluctuation of 130 mm. at the highest amplification. They state their L at 2.65.

Thus, very high amplifications are of no use if the primary galvanometer mirror has not sufficient zero stability, and for a particular set of conditions there is a limiting amplification-factor. The very highest sensitivities can only be had by the use as primary galvanometer, of an instrument having a very steady zero.

V. THEORETICAL

1. *Definitions and assumptions* :—The "distribution temperature" of a body is defined as the temperature of a black body having the same relative flux distribution as the body under consideration; the absolute magnitudes are not considered. The words "radiation temperature" are also used for this purpose, but as the American Institute of Physics proposed before their temperature Symposium held in New York in Nov., 1939 to use these words for the temperature of a body as determined by Stefan's law, ambiguity is avoided by adapting the above-mentioned nomenclature. The "colour temperature" is defined, on the other hand, as the temperature of a black body to which the body under consideration can be closely matched in colour (the visual effect of the spectrum). This is the same as the "distribution temperature" if the

source has no discontinuous radiation in the visible range, as in incandescent tungsten. Otherwise the two differ more or less widely. Thus, in the case of the high intensity carbon arc, where the discontinuous cyanogen radiation from the arc stream is superimposed in the violet region upon the continuous radiation due to the incandescent carbon, the distribution temperature estimated by disregarding this radiation is about a 100°K lower than the colour temperature in measuring which the cyanogen radiation necessarily intrudes.⁷ Moreover, for incandescent tungsten, which approximates to a gray body, the "colour or "distribution temperature" is near the "true or actual temperature," differing by 7° at 1000°K and 154°K at 3600°K , true temperatures. On the other hand, for sources of discontinuous radiation, the distribution temperature has no meaning and the colour temperature may differ very widely from the true temperature. Thus, the colour temperature of the blue sky, which is actually very cold, may be $25,000^{\circ}\text{K}$.

2. "*Distribution Temperature*" and *Spectral Intensity Distribution* :— The measurements on all sources of continuous radiation were carried out at 9 equidistant points in the wavelength range 7000 to 5000 Å. U., at intervals of 250 Å. U. This gave directly 9 values of the flux F against the corresponding values of λ . This distribution temperature was to be derived from these pairs by Wien's black body formula,

$$F \cdot d\lambda = \frac{Ac_1 \lambda^{-5} \cdot c_2 / \lambda T}{e} \cdot d\lambda \dots \dots (1)$$

this formula being quite accurate for the range of λ 's and T 's investigated, as mentioned above.

Multiplying both sides of the equation (1) by λ^5 and omitting the symbol $d\lambda$ from both sides, we have

$$F\lambda^5 = \frac{Ac_1 \cdot c_2 / \lambda T}{e} \dots \dots (2)$$

Taking common logs of both sides, we have,

$$\log (F\lambda^5) = \log (Ac_1) - \frac{c_2 \log e}{T} (1/\lambda) \dots \dots (3)$$

$$= \log (Ac_1) - \frac{0.6219}{T} (1/\lambda) \dots \dots (4)$$

Here, we have a linear relation between the variables $\log (F\lambda^5)$ and $1/\lambda$ which can be easily found from the F , λ values. The slope of this line is $-0.6219/T$ and so, T can be found to the desired accuracy by fitting the line to the points by the "Centre of Gravity" method. The probable error of the slope and so also of T can be estimated from the scatter of points about the line. In this method the pairs of data are divided into two equal or almost equal parts, of which the means are taken, each pair of these being the C. G. of the corresponding group. The straight line is taken through the two points so obtained. The residuals taken are the differences between the calculated and observed values of the ordinates and from the arithmetical sum of these, the p.e. of the slope is calculated.

The % p.e. of the temperature T is found to be much lower than the % p.e. of the values of the flux F from which it is calculated. This is due to the particular relation between F and T .

From equation (1) we have,

$$F = A c_1 \lambda^{-5} e^{-c_2/\lambda T}$$

Differentiating both sides with respect to T , we get,

$$\begin{aligned} dF/dT &= A c_1 \lambda^{-5} e^{-c_2/\lambda T} (c_2/\lambda) (-1/T^2) \\ &= -F c_2/\lambda T^2 \\ dF/F &= -(dT/T) (c_2/\lambda T) \end{aligned}$$

which is the relation between the proportional probable errors in F and T , and so also between the % p.e.s. of the same. For an average value of $\lambda = 5000^\circ \text{ A.U.}$ and $T = 2800^\circ \text{ K.}$, the relation is

$$\begin{aligned} dF/F &= \frac{1.432 \times 10^8}{5000 \times 2800} \frac{dT}{T} \\ &= 10 dT/T \text{ approximately} \end{aligned}$$

$$\text{or, } dT/T = (1/10) dF/F$$

Thus, the % p.e. in T is expected to be roughly 1/10th of that in F . For the earlier form of the apparatus, F is uncertain probably by $\pm 4\%$ and for the later, by $\pm 1\%$. The corresponding probable errors in T as actually found in the slope of the $\log (F\lambda^5) - 1/\lambda$ line are roughly $\pm 0.2\%$ and $\pm 0.1\%$ respectively.

3. "True Temperatures" in relation to "distribution temperatures":—To derive the true temperatures T of a body from the distribution temperature T_c , use is made of the fact that in finding the distribution temperature, the flux distribution of the body at temperature T is made relatively equal to that of a black body at temperature T_c . Due to this the ratio of the flux emitted per unit wavelength interval per unit area by the black body at temperature T_c at any one wavelength to the flux emitted per unit wavelength interval per unit area by the body under consideration at temperature T at the same wavelength, will be a constant, independent of the wavelength. This constant ratio is called the "colour emissivity" of the body, in case T_c is the colour temperature; though, strictly speaking it is not an emissivity, which is defined in general as "the ratio of the radiant energy emitted per unit time and per unit area by a body to that emitted by a black body at the same temperature"⁽⁸⁾. Here the comparison is made with a black body at a different temperature; however, the usage is retained as it is convenient. The colour emissivity need not be actually derived to arrive at the true temperature. A knowledge of the spectral emissivities at any two wavelengths in or about the spectral range, at the temperature considered, suffices for this purpose.

Thus, as stated above, the ratio of the flux emitted by the body at temperature T to that emitted by the black body at temperature T_c at wavelength λ_1 , being a constant, is equal to the ratio at another wavelength λ_2 .

$$\text{i.e. } \frac{(F\lambda_1)T}{(F\lambda_1)T_{cb}} = \frac{(F\lambda_2)T}{(F\lambda_2)T_{cb}}$$

where the subscripts T_{cb} and T outside the brackets, denote respectively "For a black body at temperature T_c " and "For the body under investigation at temperature T ," and $F\lambda$ denotes the flux emitted per unit wavelength interval per unit area at wavelength λ .

Using equations (2) and (3), we have, from the above,

$$\frac{Ac_1 \lambda_1^{-5} \cdot e^{-c_2/\lambda_1 T_{cb}} \cdot d\lambda_1}{AE_{\lambda_1} c_1 \lambda_1^{-5} \cdot e^{-c_2/\lambda_1 T}} = \frac{Ac_1 \lambda_2^{-5} \cdot e^{-c_2/\lambda_2 T_{cb}} \cdot d\lambda_2}{AE_{\lambda_2} c_1 \lambda_2^{-5} \cdot e^{-c_2/\lambda_2 T}}$$

where E_{λ_1} and E_{λ_2} are the normal spectral emissivities at wavelengths λ_1 and λ_2 respectively, for the body at temperature T .

From the above, it follows that

$$E_{\lambda_1} \cdot e^{-c_2/\lambda_1 T} \cdot e^{c_2/\lambda_2 T} = E_{\lambda_2} \cdot e^{c_2/\lambda_2 T_c} \cdot e^{-c_2/\lambda_1 T_c}$$

whence,

$$\frac{c_2}{T} \left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1} \right) = \frac{E_{\lambda_2}}{E_{\lambda_1}} \cdot e^{c_2 \left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1} \right) \left(\frac{1}{T_c} - \frac{1}{T} \right)}$$

Taking natural logarithms of both sides, we have,

$$\frac{c_2}{T} \left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1} \right) = \ln \left(\frac{E_{\lambda_2}}{E_{\lambda_1}} \right) + \frac{c_2}{T_c} \left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1} \right)$$

$$\text{and, } T = \frac{T_c \cdot C_2 \left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1} \right)}{T_c \cdot \ln \left(\frac{E_{\lambda_2}}{E_{\lambda_1}} \right) + C_2 \left(\frac{1}{\lambda_2} - \frac{1}{\lambda_1} \right)}$$

Tungsten being a metal commonly used for making filaments of incandescent lamps, its various emissivities have been studied and measured by many workers. The results are given in tabulated form, under the heading "Properties of Tungsten," ranging from 300°K to 3600°K increasing by steps of 100°K, on page 1318 of "Temperature, Its Measurement and Control in Science and Industry," issued by the American Institute of Physics. The special emissivities are given for wavelengths 6500 A.U. and 4670 A.U. these being the general effective transmission wavelengths of the red and blue glasses used in optical pyrometry. The colour emissivity, the brightness temperature for 6500 A.U. and the colour temperature calculated from these values of spectral emissivities are also given in the table. Because in the case of the lamps measured by us, the colour temperature is the same as the distribution temperature, it is a simple matter to interpolate the true temperatures from the colour temperatures given, the values being sufficiently close together to admit of exact interpolation to the fourth figure.

VI. RESULTS

The distributions of flux in the spectra of various sources emitting continuous radiation and of two sources of line spectra have been measured by this experimental arrangement, and the results tabulated in Tables 3 to 9.

TABLE NO. 3
*Flux Distribution and Temperature
of Special G.E.C. Lamp*

Wavelength in A.U.	Flux (Relative)
7000	1880
6750	1760
6500	1670
6250	1500
6000	1330
5750	1110
5500	969
5250	825
5000	631

Colour Temperature, 2931°K.
True Temperature, 2851°K.

TABLE NO. 5
*Flux Distribution and Temperature of Pointo-
lite Tungsten Bead (220 Volt Connection)*

Wavelength in A.U.	Flux (Relative)
7000	1690
6750	1650
6500	1450
6250	1240
6000	994
5750	909
5500	740
5250	605
5000	424

Colour Temperature, 2698°K.
True Temperature, 2634°K.

TABLE NO. 7
*Flux Distribution and Temperature
of 230 Volt—100 Watt Lamp*

Wavelength in A.U.	Flux (Relative)
7000	895
6750	700
6500	680
6250	635
6000	554
5750	495
5500	403
5250	324
5000	221

Colour Temperature, 2828°K.
True Temperature, 2755°K.

TABLE NO. 4
*Flux Distribution and Temperature of Pointo-
lite Tungsten Bead (240 Volt Connection)*

Wavelength in A.U.	Flux (Relative)
7000	1920
6750	1900
6500	1700
6250	1450
6000	1180
5750	1040
5500	811
5250	641
5000	452

Colour Temperature, 2598°K.
True Temperature, 2539°K.

TABLE NO. 6
*Flux Distribution and Temperature
of 230 Volt—40 Watt Lamp*

Wavelength in A.U.	Flux (Relative)
7000	1560
6750	1560
6500	1330
6250	1100
6000	892
5750	796
5500	670
5250	548
5000	407

Colour Temperature, 2690°K.
True Temperature, 2626°K.

TABLE NO. 8
*Relative Intensities of Copper Lines
(4 amp. arc. in air)*

Wavelength in A.U.	Flux (Relative)
5782	134
5700	136
5219	550
5153	363
5106	900

TABLE No. 9

Relative Intensities of Mercury Lines (Quartz arc, various currents)

Currents — Amp. λ	RELATIVE INTENSITIES						
	2.25	2.65	3.15	3.45	3.9	4.5	4.9
5791	26	29	33	33	40	45	56
5770	39	41	43	54	64	71	87
5461	320	3330	360	370	450	460	530

The special G. E. C. lamp (Table 3) is of the type used as the standard lamp to provide calibration density marks for photographic photometry by the method of Johnson and Tawde, to whose specifications it is specially constructed by the General Electric Company, Wembley, and made available in this laboratory. The special features of the lamp are that (1) its filament is in the form of a vertical narrow spiral making it specially suitable for spectroscopic purposes, and (2) it has a thin quartz window for use in the ultra-violet. The recommended current is 1.9 amps. and the potential drop across the lamp terminals at this current is about 12 volts. The lamp was maintained at the above current during measurements by a rheostat. Even with this current, low as compared to those taken by the Kipp and Zonen band lamp, the light is intensely white (colour temperature, 2931°K) and is concentrated in a small slit-like area. The convenience in use is evident, as ordinary flexible wires, lead fuses, and low-current-carrying rheostats could be used, whereas with the Kipp and Zonen lamp used with workshop flexible, copper fuses and thick Nichrome wire resistances, much heating would occur in the circuit and fuses blow sometimes in the middle of a set of readings causing much inconvenience.

The Pointolite lamp was operated with two different connections. It had a special ballast unit with it for operating the lamp on voltages of 40, 100, 110, 220 and 240. The d.c. line voltage in the laboratories is specified at 230, so that the lamp was usually operated on the 240 volt connection. It could also be run on the 220 volt connection with a slight overload, and with this connection the brightness and temperature were higher. (Tables 4 and 5).

Observations for 230 Volt, 40 watt and 100 watt lamps have also been taken. (Tables 6 and 7).

The results for the line spectra (Tables 8 and 9) are unsatisfactory due to the difficulty of getting a source steady in operation and having sufficiently intense lines in the region investigated. Both the arcs were disappointing in the former respect and it was necessary to adjust the current before each reading. In spite of these adjustments and the large number of readings taken, these values are probably in doubt by $\pm 10\%$.

VII. CONCLUSIONS

In this paper a fairly exhaustive account of experimental set-up developed in this laboratory for direct photometry has been given. As the ultimate aim is to use this set-up for purposes of comparison with Johnson and Tawde's method of photographic photometry, the possible future line of development is indicated here.

The set-up can also be used as a direct-reading micro-densitometer, and enough sensitivity is available for this purpose. This use can be parallel to and simultaneous with its use as objective photometer. The comparisons can then be made under conditions as nearly identical as possible.

As the above-mentioned method of photographic photometry has been used almost exclusively for measurements of gross intensity-distributions in band-spectra, it is proposed to study the comparisons also in these. Certain features of the measurements of these types of distributions might be mentioned here in connection with direct measurements. Ornstein and Brinkmann⁹ have shown, by extensive work on the violet system of CN in the carbon arc, that (a) the maximum intensity just near the head of an unresolved band, i.e. the peak intensity, is proportional to the integrated intensities of the lines composing the band, subject to the limitation pointed out by Tawde and Patanker¹⁰ that the peaks should occur at nearly the same J value, and (b) each band-head can be considered as part of a continuous spectrum, obviating the necessity of applying the dispersion correction. As high resolution is not required, large slit-widths can be used and comparatively more flux obtained for measurement. Even then, the sources will have to be of high intensity, the other requirement being steadiness of operation, because the general level of intensity should not alter during the time elapsing between successive measurements of adjacent bands. High intensity with steady operation, is, in practice, obtainable only in a very few cases.

The photographic method, on the other hand, is not so exacting in its demands in this respect, so that comparisons will be limited only by the limitations of the direct method. However, in the few cases in which it can be done, one may rightly expect valuable information.

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NOTES AND NEWS

Integrated Education

THE First World War (1914-1918) was supposed to be a war to end all wars. When the armistice was signed in 1918 there was a great rejoicing and it was thought that that would be the beginning of an era of peace. But that hope was not fulfilled and in less than 25 years, the Second World War (1939-1945), much more terrible than the first, began. It was a war in which science played the most important part. It was a total war carried on all fronts and affected the civilian population as well. It was a most destructive war benefiting neither the victors nor the vanquished. It was a war from the dire effects of which millions of people are still suffering. Though the Second World War is over since 1945 peace is not yet established. And as if that is not enough there are whispers and rumours and even open talks of a Third World War. A mad race in the building of armaments and manufacture of atom bombs and other destructive weapons of war is going on at present and millions of pounds are being spent on them. Will the Third World War, if it does come off, usher in an era of peace? Most probably not. War cannot bring peace.

The little good that war may have done in stimulating science and accelerating researches is not at all commensurate with the immense loss of precious life, property and art treasures and destruction of natural resources sustained by the world and billions of money spent on them. In military researches the efforts of science are mainly directed to the purpose of pure destruction. Science and scientists are being exploited by the military for their own purposes. Science, which is knowledge, is neither good nor bad. Scientists are not to be blamed for any misuse of their investigations and inventions. It is the people who make use of this knowledge for destructive purposes, who must be held responsible for its misuse.

What should be done to prevent these recurring crises in human affairs? In what way could the scientists of the world help to solve this problem?

Economic and political systems and institutions may be at fault; policies and ideologies may have a faulty basis. But fundamentally, man is at fault, for it is he who is the maker and creator of policies and institutions. Confusion and chaos, fear and insecurity are found within man himself and they are reflected in society and the outer world. It is the individual who forms society and state and so it is he who requires to be tackled. When truth and freedom, order and peace, justice and righteousness, love and compassion, sacrifice and service are established within the individual, not by forceful compulsion from without but by an inner conviction and compulsion then they will be reflected in the

outside society. It is this inner conversion in man which will bring about a change in society and when that is done, the menace of a future war will no longer be there.

How could this inner conversion, this change of heart, this change in mental outlook, this change on the psychological level, be brought about? Our present day education and orthodox religion, and our scientific training and discipline* have, more or less, failed to bring about these changes.

What is wanted is a rational and valid philosophy of life based on the most recent researches in science and psychology, showing the true nature and constitution of man, his purpose in life, his goal and destiny, and his relation with the outside universe. What is required is the orientation of the university curriculum to metaphysics and philosophy, for "man is a philosophizing animal" says modern science. Man is a metaphysician and philosopher at core, whether he believes in it or not, whether he likes it or not. What is needed is a system of "Integrated Education."† What is needed is an integrated view of life in which man lives a whole life and this he can do only when he ceases to drift on the ocean of life like a log of wood but takes himself in his own hands and tries to discover what he really is. In order to make this discovery he will have to go through a certain kind of tried discipline which the seers and sages of all times have shown and left for us to follow. This will bring about a change of heart and of mental outlook and introduce us to a new way of life. This will bring into being a new type of people who are self-controlled, pure-minded, far-sighted, who have a clear vision and who are able to guide themselves. These people will not live a complacent life or a life of slothfulness, both physical and mental. But they will form a group of people who are intellectually and divinely discontented, who are dissatisfied with the present state of affairs in society and who are keenly anxious to do something to put it on a better basis, who have a spirit of adventure in them, who do not think compartmentally in terms of caste and community, creed, race and province, but who consider themselves as citizens of the whole country, nay even of the entire world. They will be among those who believe in right thinking, broad-mindedness, large-heartedness, tolerance, amity and fellow-feeling, love and corporate activity, selflessness in work and self-imposed discipline, and finally, who believe in and work for a happy blending of what is best both in the West and the East.

D. D. KANGA

* See *Notes and News*, this Journal, March 1945.

† See the article on "The Foundation for Integrated Education, Incorporated," in *Main Currents in Modern Thoughts*, p. 83, October 1947, New York.

BOOK REVIEWS

Foundations of Chemical Theory, by Charles Simpson. University Tutorial Press Ltd., London, 1947. Pp. VIII + 220, 74 Figures.

THE book gives a clear, simple and concise account of the fundamental principles of Theoretical Chemistry. The difficult parts of the subject are presented in a form easily understood. The subject matter in each chapter has been brought up-to-date and illustrated with a large number of neatly drawn diagrams. For students studying for the B.A. and Subsidiary B.Sc. Examinations of the Indian Universities, the book will prove very useful, and provide a firm foundation for the Higher Examinations also. One special feature of the book is a number of thought-provoking questions given at the end of each chapter, selected from recent Higher Certificate and Scholarship Examination Papers. Answers to Numerical Examination Questions are given at the end of the book.

—D. D. K. (Bombay)

The Atom. By Sir George Thomson. Pp. 196. Third Edition, 1947. (The Home University Library of Modern Knowledge). 5s. net.

THE First Edition of the book was published in 1930 ; the Second Edition in 1937. The present edition is revised and brought up-to-date by the author who is the Winner of the Nobel Prize for Physics and who has taken a leading part in the recent researches into the nature and applications of nuclear energy. This new knowledge is given in the present edition in some additional chapters on 'atomic energy.' They are : 'Atom Splitting,' 'Nuclear Energy,' 'Some Outstanding Problems of the Nucleus.' The last chapter on 'General Conclusions' affords very interesting reading. The book brings out the most recent ideas about the structure of the atom and on atomic energy. Though written for non-specialist readers, it is in every way authoritative and treats the fundamentals in a lucid, interesting and instructive manner.

—D. D. K. (Bombay)

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Determination of the Denominator of Fredholm in some Types of Integral Equations, by Ulf Hellsten, University of Stockholm, Uppsala, 1947.

Fjrelasningar och Övningar vid Kungl-Universitetet I, Uppsala, 1948.

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Department of Chemistry :

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Flora of the Ipswich Coal Measures—Morphology and Floral Succession, by O. H. Jones and N. J. De Jersey.

Microspore Types in some Queensland Pennian Coals, by N. J. De Jersey, Vol. III, Nos. 3, 4, and 5.

Faculty of Engineering :

Tables of Beam Deflection Functions, by A. J. M. Stomay, Vol. 1, No. 8.

The Bull-dog Wau Road, by W. J. Reinhold.

Spectrophotometric Investigation of Molecular Bands of CN and CH in Stars of late Spectral Types, —a, by Torsten Setterberg, Stockholm, 1947.

Studies in Gold-Platinum Alloys, by C. G. Wictorin, Stockholm, 1947.

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INSECT PESTS OF FRUITS AND FRUIT-TREES IN THE DECCAN*

BY (THE LATE) V. G. DESHPANDE, M.AG., PH.D.

AND

K. R. KARANDIKAR, M.SC., PH.D.

Mango hoppers (*Idiocerus atkinsoni*, Leth.)
(*I. niveosparus*, Leth.)
(*I. clypealis*, Leth.)

NATURE of Damage. Tender leaf-shoots and buds are attacked for feeding and egg-laying purposes. Nymphs and adults suck out the juice from the florets which are consequently incapacitated from setting. Egg-laying in the inflorescence causes the latter physical injury, which ultimately withers and drops. Secretion of honey-dew forms a thick and sticky encrustation on leaves and branches and invites the growth of the black "mildew" fungus. It is a *very serious* pest and causes heavy loss to the mango crop.

Locality and Appearance. It is found all over the Presidency in the mango tracts. There are two seasons of the activity of these hoppers, *June* and *December*. In June the tender shoots and buds are attacked. From December onwards the inflorescence is damaged due to feeding and egg-laying. From the economic point of view the second attack during the blossoming season is the most serious.

Food plants. Mango.

Description and Life-history. The "mango hopper" includes three different species of the Jassid bug—*Idiocerus* which is a small grey wedge-shaped insect, with wings sloping at an angle over the back. *I. atkinsoni* is the largest of the three, carries two black spots on its vertex and usually hides by day under the bark of the tree trunk. *I. niveosparus* is slightly smaller, carries a median dark patch on its vertex, has a prominent white bar across its dusky wings and is usually found on the underside of the leaf. *I. clypealis* is the smallest form, has two black spots on its vertex and another pair on clypeus and is always seen on the underside of the leaf. Of the three species *I. atkinsoni* is present throughout the year in varying numbers on the bark and other sheltered places on the mango tree, while the other species usually make their appearance during the flowering season from December onwards.

* The account given in this paper was worked out by the Junior author in co-operation with Senior author during 1936-38. The senior author was then serving as the Entomologist in the Agricultural College, Poona, and the junior author was working in the Entomology Laboratory of the same College in an honorary capacity.

Eggs are laid on the soft tissue of the inflorescence, shoots and buds. Egg-laying lasts from 3-4 days. Nymphs on hatching feed on the tender florets. After 8-10 days the adult stage is reached. Total life-cycle from egg to adult requires about 2 weeks, and generally 2-3 generations are produced in the flowering season when their numbers increase rapidly and the pest becomes a menace to the mango garden. Of the three species, *atkinsoni* and *clypealis* are more commonly met with in the Bombay Presidency, than *niveosparsus*.

Control Methods.

(1) Spraying of a contact insecticide such as the Fish oil Rosin Soap controls the pest in the nymphal stage (1 lb. F.O.R.S. to 10 gallons of water), but has very little effect upon the adult. Moreover it has to be repeated over two or three times and so is not economic.

(2) Sulphur dusting has been found to be most efficient in controlling this pest in all its stages. Its action against the hoppers is deterrent and against the mildew fungus, curative. Three dustings are necessary, at an interval of a fortnight each, to obtain an effective control.

Mango-stem borer (*Batrocera rubra*, Lin.)

Nature of Damage. Both the beetles and the grubs bore into the mango stem which, as a result of the damage, may sometimes succumb and die. The attacked stems show holes from which saw-dust-like frass is seen coming out. If the stem is badly riddled, the tree looks sickly and may ultimately die. It is an *occasionally serious* pest of mango, but of usual occurrence.

Locality and Appearance. The pest is found in all the tracts of the Presidency where mangoes are grown and is active all the year round.

Food plants. Mango, Fig.

Description and Life-history. The beetle is a large-sized insect, about 1½ inches in length, greyish in colour and carries long 11 jointed antennæ. There are two orange-coloured spots on the prothorax and a white velvety line at the sides of the abdomen. Eggs are laid in or under the bark of the tree and the grubs on hatching tunnel into the stem. The grubs are legless, white, with strong mandibles and measure about 2 inches or more each. The full grown larva pupates in the tunnel, from which the adult emerges after about a month. The period of life-history is not known, but may extend over several years.

Control Methods.

(1) Introduce a flexible pointed wire into the zigzag larval tunnel and pierce the grubs inside and thus kill them.

(2) Clean the holes and inject borer solution or ordinary petrol into them and close them with mud. The borers will be killed by the poison fumes. Previous to injection of petrol, locate the holes

and close them with mud. Inspect them next day. Those that are opened through indicate the presence of borers inside and should immediately be treated as above.

(3) Dead trees should be cut, broken open and the borers inside destroyed.

Mango stone Weevil (*Cryptorhynchus mangiferæ*, Fb.)

Nature of Damage. The grub feeds on the contents of the mango stone and pupates inside. The weevil on emergence bores its way out through the pulp, thus causing damage to the mango fruit which loses its market value. Ordinarily it is a minor pest, but occasionally it does considerable damage to the mango crop.

Locality and Appearance. The pest is mainly prevalent in the Karnataka, in some sweet varieties of mango, from *April to May*.

Food plants. Mango.

Description and Life-history. The weevil is about one-third inch long, dark-grey in colour, with darkish bands on elytra. Its snout lies hidden under the body and hence its scientific name. Eggs are probably laid in a young fruit which, the grubs on hatching, bore and enter the mango stone and feed on its contents. The full fed grub pupates inside the stone and the weevil on emergence bores its way out through the pulp which is thereby spoilt and the fruit rendered useless for the market. Life-history of this weevil has not been thoroughly investigated, but it is surmised that one brood is produced annually, the pest over-wintering in the adult stage on the bark of the tree trunk or in the soil.

Control Methods.

- (1) Destroy one year's crop of mangoes.
- (2) The bark of the affected trees at some height above the soil should be sprayed with kerosine emulsion.
- (3) The soil round about the affected trees should be dug out to expose the hibernating weevils. The dug up area may also be flooded to achieve the same purpose.

Mango spring caterpillar (*Parasa lepida*, Cr.)

Nature of Damage. The caterpillar is a leaf eater of mango and feeds gregariously in its young stages. The hairs on its body are very poisonous and care should be taken when handling them. It is an occasionally serious pest of mango and its appearance is sporadic.

Locality and Appearance. It is found all over the Presidency and remains active during the rainy season from *June to October*.

Food plants. It has a wide range of food plants amongst which the following are important:—Mango, castor, pomegranate, wood apple, plantain, etc.

Description and Life-history. The moth has its forewings greyish brown with a median green patch. Eggs are laid on the leaves in masses and the young caterpillars on hatching feed gregariously on leaves. The full grown caterpillar is about $\frac{3}{4}$ inch long, squat, and stout. It is bright green in colour with longitudinal blue stripes dorsally and laterally. Rows of warts are present on the body from which arise thick branching brushes of short, spinous, stinging hairs. In walking the legs are not visible and the caterpillar moves with a slug-like motion. It pupates in a tough shell-like rounded cocoon found clustered and fixed to the tree trunk. Other details of life-history are not known.

Control Methods.

- (1) Wherever possible hand-pick the caterpillars which usually feed gregariously on leaves in the early stage.
- (2) Destroy the pupal cocoons on the tree trunks.
- (3) Spray a stomach poison if found practicable.

Mango hairy caterpillar (*Euproctis scintillans*, Wlk.)*

Nature of Damage. The caterpillar is a leaf eater of mango and may feed on the inflorescence too. It is usually a minor pest but may occasionally become serious.

Locality and Appearance. The pest is found in all parts of the Presidency and usually remains active from September to March.

Food plants. Mango, castor, onions, sannhemp.

Description and Life-history. It is a large-sized yellow moth, hairy, with fore wings buff-coloured and carrying 3 yellow spots on the outer margin. Eggs are laid on lower surface of leaves in clusters covered with hairs. Larvæ on hatching feed gregariously for a while on leaves and inflorescence. A full grown caterpillar is stout, dark-coloured, bears tufts of hairs on its body and carries dorsally a median yellow stripe. Pupation takes place in a silken cocoon in the folded leaf. Total life cycle requires about 30-40 days. Other details are not known.

Control Methods.

- (1) Hand-pick the caterpillars in the young stage when they are usually found feeding gregariously and destroy them.
- (2) Spraying or dusting may also be tried where practicable.

**Euproctis fraterna*, Mor. is another species of hairy caterpillars which is found feeding on castor, cotton, and pomegranate. The moth is very hairy and its fore wings are yellow with 3 minute reddish brown spots near the outer margin. The caterpillar is hairy, dark reddish in colour, and has its head and prothorax orange red. In other respects it is similar to the *scintillans* species. Measures of control recommended for the latter species are equally applicable for this pest also.

Red ants (*Ecophyla smaragdina*, Fb.)

Nature of Damage. These social ants web together leaves of mango and other trees and build nests in there. Indirectly they interfere with the normal growth of shoots and cause unbearable annoyance to persons gathering the fruits on trees. To that extent only it is fruit-pest.

Locality and Appearance. The ants are found all over the Presidency on mango and other trees and are seen to be active throughout the year.

Food. Caterpillars, flies, honey dew, etc.

Description and Life-history. The female is a winged insect and greenish in colour. The workers are wingless and rusty red in colour. The males are also green in colour and winged. The nests are made by the workers and defended by them. The details of life history are not worked out.

Control Methods.

- (1) Remove and burn the nests if possible.
- (2) Break open the nests slightly and dust Calcium cyanide or Katol into them.

Fruit flies (*Trypancidae*-Diptera)

There are 6 species of *fruit flies* found attacking different fruit crops in the Presidency. All the species, the details of which are given below, are *serious* fruit pests.

- (1) *Carpomyia vesuviana*, A. costa —on Ber (*Zizyphus jujuba*).
- (2) *Chatodacus cucurbitae*, Cog. —on Cucurbits.
- (3) *Ch. correctus*, Bezzi. —on Mango, Orange, Chikku.
- (4) *Ch. zonatus*, Saund. —on Mango, Guava, Chikku.
- (5) *Ch. diversus*, Coq. —on Mango, Guava.
- (6) *Ch. ferrugineus*, F. —on Mango, Guava.

The *distinguishing characters* of these are as follows in the serial order :—

- (1) Greyish. 7 pairs of black spots on thorax, wings crossed by four brownish patches.
- (2) Reddish brown in colour, hind cross vein infuscated.
- (3) Facial spots form an archlike suture, reddish in colour, small in size.
- (4) Reddish yellow in colour, wings with apical brown spot, thoracic median yellow line may or may not be present.

(5) Female thorax black with a median yellow stripe, ovipositor long and black. Facial black spots form an arch. Male facial spots wanting. Rest as in female.

(6) Size large, back black, costa brown, scutellum tip blackish, median black and laterals yellow.

Nature of Damage. Ripening fruits of various kinds are infested with maggots of these flies, which burrow in the soft tissue, feed upon the pulp and render the fruit inedible and valueless for the market.

Life-History. Fruits are attacked when they approach the ripening stage, the female laying whitish elongate eggs in the tissue of the fruit by piercing it with its short pointed ovipositor. Whitish legless maggots hatch out after 3-4 days and feed on the pulp. They grow as the fruit ripens and when full grown after about 10 days, they leave the spoiled fruit, drop to the ground, wriggle about for a while and pupate in the soil in a suitable place. Adult emerges in about a week and once again carries on the infection in the same manner. Details of life history may vary slightly in different species in different fruits, but generally about 3 weeks are required from the egg to the adult stage. Detailed information in regard to the life history and periods is however wanting.

Control Methods.

(1) The critical point in the attack of these pests is the first brood. If due precautions are taken against the production of this brood, subsequent productions can easily be checked and damage minimised.

(2) Affected fruits should be collected and buried deep or boiled in water.

(3) Twigs dipped in the poison bait (Lead arsenate with gur solution) should be hung on fruit trees and protected with a tin cover to keep off rain. Flies feed on this and get killed.

(4) Flies may also be trapped by hanging "lure" cages or bottles between the branches of the fruit trees.

Orange fruit moth (*Ophideres fullonica*, Lin.)

(*O. materna*, Lin.)

(*O. ancilla*, Lin.)

Nature of Damage. The adult moth has the tip of its siphon tube toothed and sawlike, by means of which it punctures the soft rind of oranges, pomelo and even mangoes and sucks in the sweet juices. The fruit falls off and the crop is seriously spoiled. The moth is a serious pest of citrus fruits and provides a solitary instance of adult Lepidoptera committing damage.

Locality and Appearance. The pest is found in all the citrus growing tracts of the Presidency during the fruiting season (October to March).

Food plants. Orange, musumb, pomelo, mango.

Description and Life-history. Of the three species, *fullonica* and *materna* are commonly met with. All the species are nocturnal in habits, attack the fruits at night and remain in hiding by daytime. Life-history details are not worked out.

Control Methods.

- (1) Screening the fruits in paper bags or lotus leaves is found to keep away the moths and thus prevent damage.
- (2) Collection with handnets may also be tried.
- (3) Poison baits (alcoholised mixtures) have been found to attract moths.

Lemon caterpillar (*Papilio demolius*, Lin.)

Nature of Damage. The caterpillar feeds openly on the leaves of lemon, orange, and citrus plants particularly in the young stage of the crop. When *abundant*, the pest may defoliate the plants completely and cause *severe* damage to the citrus crop.

Locality and Appearance. The pest is present all over the Presidency and remains active *throughout the year*.

Food plants. Citrus, Bel, and a weed called Bavachi.

Description and Life-history. The adult is a large-sized butterfly with black coloured wings carrying yellow marks on the front pair and a brick-red spot at the toral angle on the hind pair. Eggs are laid singly on the top leaves and are round and greenish white in colour. The young larva is darkish brown and carries an irregular, broad, conspicuous white bar across its back and closely resembles the droppings of birds. When disturbed, a yellowish, retractile forked process juts out from the prothorax, serving perhaps as a means of defence. The full grown larva is greenish brown with brownish cross bars on back. The full grown caterpillar pupates on the plant by fixing itself by the tail and by a thread round its body which is fastened on each side to the plant. The larval and pupal periods are each of about a fortnight's duration.

Control Methods.

- (1) Handpicking the larvæ is the simplest and cheapest remedy.
- (2) Spraying a stomach poison may be done if possible.
- (3) Collection of butterflies by hand-nets.

Citrus leaf miner (*Phyllocnistis citrella*, St.)

Nature of Damage. The tiny caterpillar is a leaf miner which burrows between the epidermal layers and feeds upon the green matter. It does serious damage in the case of young citrus plants whose foliage gets deformed and spoiled. This is often seen in nurseries.

Locality and Appearance. The pest is prevalent in the citrus growing areas and is found to be active during the *monsoon period*.

Food plants. Citrus, Bel.

Description and Life-history. Eggs are probably thrust in the leaf tissue. The larvæ on hatching burrow in the leaf. Pupation takes place in larval mine from which in due course the adult emerges. Further details of life-history are not known.

Control Methods.

(1) Affected plants may be treated with a mixture of C. O. E. and tobacco extract, the latter having a penetrative action on leaf tissue. The larvæ and pupæ inside are killed. Fish oil Rosin Soap may also be used.

(2) Spraying of Nicotine sulphate may be tried.

(3) Fumigation of affected plants may be done.

Citrus bark-borer (*Arbela tetraonis*, Moore.)

Nature of Damage. The caterpillar eats the bark under cover of a silken gallery which leads into a tunnel excavated into the tree, usually in the angle of a branch. It is a *serious* bark-boring pest.

Locality and Appearance. The pest is found all over the Presidency and the period of larval activity extends from July to the following April.

Food plants. Citrus plants, guava, mango, jak, ber, etc.

Description and Life-history. The moth is without any proboscis, has its front wings speckled brown and hind wings clear. Antennæ of the male are bipectinate. Eggs are laid singly in crevices of bark. The caterpillar on hatching feeds on bark under cover of a silken gallery overlaid with woody fragments. The full grown caterpillar is stout-bodied, flattened in form and earthworm-like in colour. Pupation takes place in the larval gallery. Pupa is red brown in colour and carries rings of hooks on its segments.

According to Fletcher, eggs are laid in the beginning of the monsoon, larvæ remain active throughout summer and winter seasons. Pupation takes place in April-May and moths emerge in May-June and commence their cycle over again. Full details of life-history are however not worked out.

Control Methods.

(1) Caterpillars may be hooked out with a piece of wire and destroyed.

(2) *Borel solution* (2 parts of chloroform plus one part creosote), may be syringed into the gallery and the mouth plugged with wet clay or tar.

Citrus white fly (*Aleurocanthus spinifera*, Gut.)

Nature of Damage. Leaves of citrus are thickly covered with the nymphs of this black spiny Aleurodid which sucks out the sap from the leaf tissue. Exudation of honeydew is so profuse that it forms a thick covering on leaves and causes the growth of black fungus. The pest is *occasionally serious*.

Locality and Appearance. The white fly is found in the citrus tracts of the Presidency, particularly in the *monsoon period*.

Food plants. Orange, lemon, pomelo.

Description and Life-history. Eggs are laid in spirals on the lower surface of leaves. They are elongate oval in form, and pale yellow in colour which shortly changes into orange brown. Nymphs on hatching move but little and remain stationary, thrust their beak in the leaf tissue and suck out the juice. Further details of life-history, periods, and description are wanting.

Control Methods.

- (1) Collect and burn all leaves infested with this pest.
- (2) Spray C.O.E. nearly three times at intervals of a fortnight each.

Citrus scale (*Chrysomphalous aonidium*, Gr.)

Nature of Damage. Both the nymphs and adults attack the fruits and leaves of citrus plants. The fruits are often covered with these scales which interrupt their growth; appearance is spoiled and the fruits rendered useless for the market. Plants look sickly. The scale is an *occasionally serious* pest, though of usual occurrence.

Locality and Appearance. The pest is found all over the citrus growing areas, *throughout the year*.

Food plants. Citrus.

Description and Life-history. The scale has wingless females and winged males, with only one pair of wings. Yellowish eggs are laid on leaves and fruits. Newly hatched young ones which are also yellowish in colour wander about on leaves and fruits for a while and then fix themselves on suitable places for feeding purposes. As they grow, two kinds of nymphs develop: some are narrow and elongate and ultimately produce the winged males. Others are circular in form and develop into females. After mating eggs are laid on leaves and fruits, the males and females dying away. About 6 generations are produced in a year. Detailed information in regard to life-history is however wanting.

Control Methods.

- (1) Spraying of Fish Oil Rosin Soap should be done in the early stage of the infection. It may be repeated.
- (2) The infected dried leaves should be collected and burnt to stop further infection.

Citrus aphid (*Toxoptera aurantii*, Koch.)

Nature of Damage. The aphid attacks the young shoots of *Citrus*, sucks the juice out of them and thus causes *serious* injury to the growing parts and the plant in general.

Food plants. Citrus, orange, musumb, sour lime, etc.

Description and Life-history. The adult aphid is shining dark brown in colour and has the *media vein* of its wing "one-branched"—a typical characteristic of this species. Other details of its life-history are not known.

Control Methods.

A contact spray such as the *Fish Oil Rosin Soap* is effective in controlling this pest.

Grape vine beetle (*Scelodonta strigicollis*, Mots.)

Nature of Damage. The beetle is ordinarily a leaf eater, attacks grape vine leaves and buds and when abundant, defoliates it completely. The pest is *serious* in so far as it destroys the buds sprouting after October pruning.

Locality and Appearance. It is found in the vine growing tracts of the Presidency throughout the year and is very active after October pruning.

Food plants. Grape-vine.

Description and Life-history. The beetle is small in size, about $\frac{1}{4}$ inch in length, is of a metallic bronze colour, with three pairs of black spots on elytra. It hides by day under the bark and other sheltered places and feeds in the evening and at night. Nothing further is known of the life-history of this beetle.

Control Methods.

(1) Plantain brushes may be hung among the vines to trap the beetles which usually seek such shelters. These should be shaken over a pan of kerosinised water.

(2) Collection of beetles by hand-nets may also be made.

Grape vine girder (*Sthenias grisator*, Fb.)

Nature of Damage. The adult beetle has the curious habit of girdling branches and even the main stem in the case of the young vines. A groove of about $\frac{1}{4}$ inch width is eaten right through the bark all round the branch with the result that the upper portion withers and dies. It is an *occasionally serious* pest of Grape vine.

Locality and Appearance. It is present in the vine growing tracts.

Food plants. Grape vine, *Erythrina*, Rose, Oleander.

Description and Life-history. The beetle is dark grey in colour and about $\frac{1}{2}$ inch in length. Eggs are thrust into the girdled branch and the emerging larvae feed sometimes on the bark, remain there for a while, and then drop off. Pupation may take place in the branch or in the soil. Further details of life-history are not known. The beetles rest as a rule on the branch under a bunch of dead leaves, quite motionless and are apt to drop to the ground and are therefore difficult to see.

Control Methods.

(1) Removal and destruction of freshly girdled branches to prevent further breeding and subsequent damage.

•(2) Collection of beetles on vine and their destruction.

Pomegranate butterfly (*Virachola isocrates*, Fb.)

Nature of Damage. The caterpillar bores into the pomegranate fruits and buds, lives and feeds inside especially on seeds. The affected fruits become absolutely inedible and useless for the market. The pest is of common occurrence though *occasionally serious*.

Locality and Appearance. The pest is commonly found wherever pomegranate is grown and remains active in the *monsoon and cold season*.

Food plants. Pomegranate, citrus.

Description and Life-history. It is a medium-sized butterfly, about 1 inch across the wings, violet in colour with an ochreous spot in the centre of forewings and a slender tail to the hind wings. Bluish small eggs are laid singly on flowers, sometimes on fruits. The larva on hatching bores the fruit and feeds inside. The full grown caterpillar is about $\frac{3}{4}$ inch long, darkish brown in colour, slightly bristly, a little flattened and with the hind end shield-like. Before pupation it webs silk over the fruit and its stalk (apparently to prevent it from falling), re-enters the fruit and pupates, from which the adult emerges in due course.

Control Methods.

(1) All the affected fruits should be collected and burnt.

(2) Fruits should be carefully inspected and protected in tissue paper bags.

(3) Butterflies may be caught and killed.

Plantain weevil (*Cosmopolitus sordidus*, Gr.)

Nature of Damage. The weevil and its grubs bore into the root-stalk of plantain, tunnel through it and feed inside. The attack is not confined to the root stalk but may sometimes extend a little up into the stem. When the infection is severe the central shoot withers and the bearing is affected. The pest is *occasionally serious*.

Locality and Appearance. The weevil is found in all the plantain areas and is present throughout the year.

Food plants. Plantain.

Description and Life-history. The weevil is small, elongate and black, and measures about $\frac{1}{2}$ inch long, with a whitish spot on the scutellum. Eggs are probably laid in the root-stalk of the plantain. The grubs are legless and dirty white in colour, about $\frac{1}{2}$ inch long, with a reddish brown head. Pupation takes place in the larval tunnels and the adult emerges in due course. Other details of life-history are not known.

Control Methods.

(1) Old stumps should be removed and destroyed before new suckers are planted.

Palm-beetle (*Oryctes rhinoceros*, Lin.)

Nature of Damage. The beetle flies at night and bores the soft crowns of palm trees by gnawing a large hole at the base of the heart leaf. The growing point gets damaged, the tree ceases to grow, becomes sickly and ultimately dies. The subsequent attack of the *palm red weevil* and the collection of rain water in the holes and borings hasten the end. Frequently the beetle gnaws across the unopened central leaves which on opening look to have been trimmed or punched. It is a *serious pest* of cocoanut, and date plantations especially in the young stage.

Locality and Appearance. The pest is present in the palm growing tracts of the Presidency and remains active from *April to November*.

Food plants. Cocoanut and date palms.

Description and Life-history. The beetle is a big stout, black, insect with the lower surface reddish and body clothed with short pubescent hairs, on the head is situated a curved and backwardly directed horn like that of rhinoceros and hence its common name. It is nocturnal in habit and is attracted in bright light. Eggs are laid in manure pits or in decaying vegetation or in rotting trees. The larvæ hatch out after 10-12 days and live and feed in the rotting organic matter. The full grown larva measures 2-3 inches long and about an inch broad. It is fleshy and soft bodied, with the skin wrinkled transversely. There are 3 pairs of thoracic legs, a pair of powerful mandibles and a curved body. The general colour is whitish, with the head brown. The spiracles also look like brownish spots. The larval life lasts for about 10 months and when full grown it pupates in an earthen chamber, deep in the soil, the adult emerging in the following April-May and behaving in the way mentioned above. Total life cycle takes about a year, hibernation probably occurring in the larval stage in cold weather.

Control Methods.

(1) Affected palm trees should be cleansed from April-October. Boring beetles should be extracted from their burrows by means of hooked wires and the burrows should be closed up with cotton dipped in tar.

(2) Rotting vegetable matter near palm gardens should be regularly turned over and the larvæ picked out and destroyed. All dead and

rotting palms which serve for egg-laying and growth of the larvæ should be cut and burnt.

- (3) Beetles may be collected by light traps and destroyed.

Palm weevil (*Rhynchophorus ferrugineus*, Oliv.)

Nature of Damage. The grubs of this weevil feed on the soft tissue of the palm tree crowns already damaged by the palm beetle and gradually bore down the stem, causing the tree to dry up and die. The tissues mined by these grubs rot, a process assisted by the lodgment of rain water in the crown, and the latter when dead, becomes a suitable place for the *palm beetle* to oviposit and for its larvæ to develop in. The *palm weevil* and the *palm beetle* are thus mutually interdependent and between them do *serious damage* to the palm.

Locality and Appearance. The pest is present wherever the palms are grown, the period of activity lasting from *May* to *November*.

Food plants. Cocoanut and date palms.

Description and Life-history. The weevil is nearly 2 inches long and possesses a long, slightly curved snout. It is red brown in colour and carries a variable number of black spots on its prothorax. The male snout is provided with a tuft of hair above by which the sex may be recognised. Eggs are laid singly in wounds made by the *palm beetle* in the crown tissues or in cuts made through tapping. They are elongate oval in form and creamy-white in colour. The grubs hatch out after 3—4 days, feed on the surrounding soft tissues and bore through the stem. The full grown grub is about 3 inches long, legless, curved ventrally and with a wrinkled body and with 2 pairs of spiracles (first and ninth). It is whitish in colour with a brownish head. After about 4 weeks it prepares a cocoon of palm fibres and pupates in a larval tunnel, the adult weevil emerging after about 3 weeks. Total life-cycle takes about 2 months and breeding continues throughout the year, though the active season is the monsoon.

Control Methods.

- (1) All cuts and wounds in the palm tree should be closed up with a mixture of tar and sand.

- (2) Control of the *palm beetle* would automatically check the progress of the *palm weevil*.

- (3) Badly affected trees should be cut and burnt.

Cocoanut-leaf caterpillar (*Nephantis serinopa*, Meyr.)

Nature of Damage. The caterpillar constructs a gallery of silk and excrementitious matter, over the lower surface of palm leaves, eating away the green matter and reducing the leaf to a thin membrane so that it dries up and dies. In cases of bad infestation the whole leaf may be eaten up and entire fronds are reduced to mere skeletons. It is a sporadic pest and may *sometimes* cause *serious* damage.

Locality and Appearance. The pest is present in the palm growing tracts particularly along the Konkan coast.

Food plants. Coconut, and other palms.

Description and Life-history. The moth is ashy grey in colour, flattish in shape and has the habit of resting flat on the under surface of leaves or the bark of trees, so as to be inconspicuous. The male is smaller than the female and carries a conspicuous fringe of hairs at the base of the hindwings. Eggs are laid in batches of 3-10 on the lower surface of the leaf or among the frass of the larval galleries. The egg is long, elliptical and shows a pearly white network on its surface. Larvæ emerge after 4-5 days and begin to mine the leaves as described above. A full grown caterpillar is about an inch long, with longitudinal pinkish stripes on back, head and thorax being reddish-brown. After about 4-6 weeks when full grown, it pupates in the larval gallery in a tough cocoon made of silk and frass. The adult moth comes out after about 10 days. Total period from egg to the adult stage takes about 45-50 days to complete the development.

Control Methods.

Infested fronds should be cut and be destroyed.

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STUDIES ON THE INFLUENCE OF SOME BACTERIAL CULTURES IN THE NITROGEN STATUS OF SOIL

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1. The Influence of *Serratia marcescens* in the Nitrogen Status of Soil

EVEN though our information regarding the various soil processes has increased in the past years to a considerable extent, we have to admit that the accurate knowledge of the soil microflora and the microfauna and their exact activities in the soil has not advanced, as Waksman (1932) pointedly remarks, "beyond a mere beginning of a systematic study." According to him the isolation of the numerous micro-organisms from the soil, their identification and cultivation upon artificial media is very important, but such data, as he correctly opines, do not tell what role they play in the soil. According to him the problem of the various activities of the micro-organisms in the soil and the role they play in the soil processes has been the least studied. Accepting, as we do, that point of view this work was undertaken to reveal at least the activities of some species of bacteria found in the soil.

In a previous series of papers Bhat, (1942a. and 1942b.) Palacios and Bhat (1942a. and 1942b.) have already reported the way in which the chemical agencies on the one hand and the microbial agencies (collectively) on the other influence the nitrogen status of the soil. In this series it is proposed to reveal the exact influence of a few of the commonly encountered bacterial species in the soil nitrogen. It is clear at this stage of our microbiological knowledge that micro-organisms are not only concerned in the continuous processes which are more or less loosely termed as the weathering of the soils, but that micro-organisms may be expected to attack rock and soil particles and render most nitrogen available. The nitrogen incorporated into the sphere of available matter in the soil would be in the form of ammonia (NH_3) and ammonium (NH_4^+) nitrite (NO_2^-) or the nitrate (NO_3^-) state according to the stage at the time of analysis in the constantly changing nitrogen cycle.

In the previous communications, as has been stated before, the exact influence of microbial species collectively (as presented by the non-sterile samples of the soil with its known and unknown flora) in the nitrogen status was studied; in this instance the influence of pure bacterial species in the nitrogen status is undertaken as we could establish that soils could be exposed to various light-weather conditions for long periods of time with detectable results and without the fear of external contamination.

At first we thought that it would be worthwhile to inoculate the soil with a known number of particular species, but then we found in agreement with Cutler and Crump (1935) that rapid fluctuation occurs in any soil and that this is true even for soil kept under constant conditions in the laboratory. Moreover, for the very same reason, isolated observations of the bacterial numbers in a soil may give a false picture of the general level of activity. Above all, in our experiments, temperature, moisture and light-weather conditions severally and jointly were found to have a marked influence in the microbial numbers. For obvious reasons all these studies were conducted with sterile samples of the soil.

The most difficult problem was to select proper bacterial species. If we only take into consideration the known species of bacteria we realize that soil is practically the fount and origin for most of the species, but at the same time as Russel (1923) remarked, that it is conceivable that the unknown forms of bacteria may far outnumber the known and that the defect of the present methods would be that they always leave us in doubt as to the completeness of the list of bacteria. Besides, as Cutler and Crump (1935) express it, although the soil is a store house for all sorts and conditions for bacteria, yet it is probable that only a few among them are universally distributed, and these will most certainly be the forms which are able to carry out a diversity of chemical reactions.

With the variety of organisms there are some of the specialised types, and in this category may be placed the nitrogen-fixing bacteria. For this and various other reasons (chief among others the wide distribution of *Azotobacter* in Indian soils) we included *Azotobacter chroococcum* among the species chosen for our studies. The other species were selected as typical from the well recognized four main groups of Conn (1910) which are as follows :—

- I Large spore forming bacteria, related to *Bacillus subtilis*, which form about 5 to 10% of the numbers found.
- II Short non-spore forming organism related to *Pseudomonas fluorescens* that are gelatine liquefiers. These comprise another 10%.
- III Short rod forms that liquefy gelatine slowly or not at all, and develop colonies very slowly. These form 40-70% of the numbers and are therefore of considerable importance to the soil.
- IV Micrococci.

From the soil, on which our studies were made, we could isolate *B. mycoides*, *B. subtilis*, *B. megatherium*, *B. vulgaris*, *P. fluorescens*, *S. marcescens*, *Staph. albus*, *Staph. citreus*, *Staph. aurantiacus*, *A. ærogenes*, *E. coli*, *P. æruginosa* and *Azotobacter chroococcum* in greater numbers than any other species. Of these, *B. subtilis*, *S. marcescens*, *P. æruginosa*, *Staph. citreus*, *A. ærogenes*, *E. coli* and *A. chroococcum* were strikingly preponderating and so we preferred these particular organisms to any other for our experimental purposes. *B. subtilis*, as is well known, is not only an universally distri-

buted species but it is also one of those preponderating types of spore bearers found throughout the world and representing the aerobic bacilli and at the same time Conn's group I. Furthermore *B. subtilis* is an important member of the stable manure (Ruschmann 1927). Physiologically too, it is a very active species being a powerful starch hydrolyser and ammonia producer. König (1903) has shown that this organism can produce from cotton-seed meal within five weeks, albumoses, peptones, phenylacetic acid, phenyl propionic acid, mercaptan, basic amines, hydrogen sulphide, carbon dioxide, and ammonia; and, after three months indol, indol-acetic acid, skatol and even phenol is formed. It can also produce urea from proteins and under certain conditions may even hydrolyse urea to ammonium carbonate, thus bringing about a change in soil nitrogen without a direct action of oxygen according to the equation.



Much more difficult was to find an uncontested choice to represent Conn's group II, but eventually we preferred *P. æruginosa* to *P. fluorescens*: Firstly because it was preponderating in our soil sample and secondly because it is a representative of a secondary, if not altogether primary, pathogenic bacteria and chiefly because it is one of the most active organisms, being really protean in its activities. The reports of Sohngen (1907), Selim (1931), Maassen (1901), Fred (1911) and Sewerin (1897) show that this species is capable of a diversity of chemical activities including nitrogen fixation, denitrification, fat decomposition and is also able to utilize aliphatic and cyclic aminoacids as its source of energy. To represent the group III of Conn we chose *A. ærogenes* because of its ubiquitous nature, presence on grain, milk, fæces, etc., and for its nitrogen fixing and at the same time nitrate reducing properties. Moreover the conclusions drawn by Skinner (1928), Selim (1931) and Lohnis and Hansen (1921) are adequate enough to convince one of its presence or significance in soils.

As representative of group IV we favoured *Staph. citreus*. This coccus is also one of the most abundantly distributed species present in great numbers on skin, mucous membranes, mouth, fish-skin, air, water, soil and so on. Moreover staphylococci in general are physiologically very active; they can reduce nitrates to nitrites, form hydrogen sulphide from proteins, ferment a variety of carbohydrates and decompose most of the complex proteins including coagulated serum. Thus our selection included a representative set of bacteria capable of bringing about a variety of enzymatic changes. It may be mentioned however that a representative species of the cellulose-decomposer was not among the list.

Besides the five species mentioned above, we selected a strain of *S. marcescens* for the study of its influence in the nitrogen status. As the old nomenclature of this species suggests itself, viz., *Bacterium prodigiosum*, it is prodigious in nature; it is very aerobic, versatile in its action on carbohydrates and other substrates (urea, proteins, fats and nitrates) and is even capable of fixing appreciable amounts of nitrogen (Lohnis 1905). It produces a variety of products from proteins (Waksman 1932) and a unique number of acids and alcohols, including formic

acetic, succinic and levulactic acids, ethyl alcohol, acetyl-methyl-carbinol, etc. Above all this species was encountered in relatively large numbers in the soil under investigation.

All these species of bacteria were systematically identified and all their physiological capabilities were put to test before they were utilized for their influence in the "nitrogen metabolism" in soil.

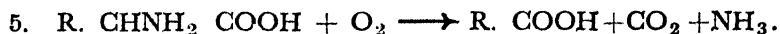
It may be desirable in this connection to make some remarks in brief, about the various ways in which the nitrogen may be lost to the soil. Apart from the losses occurring in soil due to chemical agencies (Palacios and Bhat 1942) and the leaching and other actions, microbial agencies play a significant role. Nitrate, nitrite and ammonium compounds may be reduced to elemental nitrogen in the presence of carbon, cellulose and such other organic substances. The complex proteins undergo various types of decomposition depending upon the external influences and the micro-organisms involved. But in all proteins the fundamental changes may be regarded as more or less similar in as much as all of them are hydrolysed first by acids or enzymes and broken down to aminoacids. The second stage may be considered as the decarboxylation and the deamination of these acids resulting in the formation of ammonia; a third stage may be the formation of the secondary decomposition products such as amines and the final stage in the oxido-reduction reactions which result in the formation of CO_2 , NH_3 , H_2S , H_2O , and so on.

Even though the chemical changes are various, they may be mainly considered as following a pattern of the well-known bacterial reactions, which recently have been elucidated with pure enzymes isolated from the bacteria. In general, these changes may be represented by the following general formulæ, where R stands for the ring or chain of the aminoacid.

1. $\text{R. CHNH}_2 \text{ COOH} + \text{H}_2\text{O} \longrightarrow \text{R. CHOH COOH} + \text{NH}_3$
2. $\text{R. CHNH}_2 \text{ COOH} + \text{H}_2\text{O} \longrightarrow \text{R. CH}_2\text{OH} + \text{CO}_2 + \text{NH}_3$
3. $\text{R. CHNH}_2 \text{ COOH} + \text{H}_2\text{O} \longrightarrow \text{R. CHO} + \text{HCOOH} + \text{NH}_3$
4. $\text{R. CHNH}_2 \text{ COOH} \longrightarrow \text{R. CH}_2\text{NH}_2 + \text{CO}_2$.

The above reactions do not include the 'Stickland' reaction or others as understood today. Nevertheless, out of the above reactions, reactions 2 and 4 are of common occurrence among micro-organisms; for instance the formation of isoamyl alcohol from leucine and cadaverine from lysine.

The oxidative deamination is also carried out by various aerobic bacteria as for example the formation of iso-valeric acid from leucine as per the general equation,



It is also possible that a rapid loss of nitrogen occurs in the soil due to the final oxidation of proteins to liberate ammonia, thus bringing about vital changes in the soil nitrogen balance:



But until we have definite knowledge about all the changes brought about by chemical and microbial agencies in the nitrogen status, we cannot assert any particular chemical reaction as the only or the chiefly concerned process for explaining the nitrogen changes in soil.

Experimental.—Apart from the control sets (for determining the nitrogen contents at the starting point) there were for every bacterial culture, 36 experimental samples of soil (5 grams in each) contained in 250 cc. Erlenmeyer flasks provided with bacteriological cotton plugs. These were divided into two sets of 18 flasks each, and tagged as the "sterile" and the "inoculated" series. Out of both the series, 6 samples were rendered semi-saturated by the addition of 3 cc. of ammonia-free distilled water in each of them, and another group of 6 samples were water-logged with the addition of 25 cc. of the same water aseptically. All the soil samples of the inoculated series were then inoculated with 0.1 cc. of an inoculum containing 537,900,000 cells per cc. as estimated by the opacity and direct count methods. In this experiment, a 24 hour growth of *S. marcescens* was made use of and in others the remaining chosen species of bacteria. The count was different in every case. The 36 samples were then exposed in 3 groups at 3 different light-weather conditions, viz., direct sunlight, diffused sunlight and darkness, for a period of 30 days. At the end of this period the nitrogen contents—both total and soluble—of the specific samples were estimated by a standardized and modified Kjeldahl method; the values obtained were expressed as parts per million parts of the soil, or referred to below as p.p.m.

In addition to these 36 flasks we had also others kept in identical conditions and meant for determining the viability of the bacterial forms under the various conditions. These constituted also an emergency set in so far as they could be used in case contamination was detected in the experimental samples.

The following tables will indicate the losses (or the gain) recorded in each of the differently treated samples of both the sterile and the inoculated series and under the various light-weather conditions. These tables refer to the action of *S. marcescens* in the soil.

1. DIRECT SUNLIGHT

Losses in Nitrogen contents expressed in p.p.m. of the soil

The +ve sign before the figures indicates a gain in Nitrogen.

Moisture Condition of the Soil	Inoculated Set		Sterile Set	
	Total N.	Soluble N.	Total N.	Soluble N.
Dry	2.40	+65.80	105.40	30.34
Semi-saturated	+21.53	+87.64	64.12	10.40
Water logged	82.20	+108.60	53.78	38.00

We shall not enter on this occasion into elaborate discussion of the results; only the main conclusions are drawn below.

Conclusions.—As compared to the loss occasioned by chemical agencies (observable in the sterile samples) the losses brought about in the total nitrogen by *S. marcescens* are negligible. In all cases there is an appreciable gain recorded in the water soluble nitrogen, this gain being much more pronounced in the wet samples and attributable to no other reason than nitrogen fixation (Lohnis 1905). The explanation appears to be plausible as it affords actually calculations in most of the experiments; where greater complication due to both nitrogen fixation (in excess of the initial quantities) and denitrification could not occur, as for instance, in the dry samples in the above results such a calculation is both valuable and practical. In the inoculated samples, although we should expect a loss of 105.40 p.p.m. of total nitrogen as indicated in the corresponding sterile samples, we actually observe only a loss of 2.40 parts; so the difference of 103 parts of total nitrogen (not indicated to have been lost in the inoculated total) must have been built up or prevented from being lost by the bacterium. This value is almost calculable from the soluble nitrogen and agrees with it within the experimental errors. It should however be remembered that the total nitrogen is made up of both the soluble and the insoluble form. Taking the sterile soluble sample, we notice a loss of 30.34 parts; in the corresponding inoculated sample we see actually a gain of 65.80 parts, and this gain is recorded in spite of a presumable loss of over 30 parts which must have occurred due to the chemical activities. Therefore the actual gain in the inoculated sample is the total of the gain recorded and the loss prevented or $65.80 + 30.34 = 96.14$ parts of soluble nitrogen. Now the loss prevented in the total (103 parts) is comparable with the actual total gain calculable in the soluble nitrogen and which is over 96 parts. The slight difference is explainable from the bacterial metabolism standpoint.

The increase in nitrogen appears to be due to accumulation of the water soluble form; whether this accumulation is due to a conversion of insoluble proteins into soluble form or ammonia or nitrates, is not clear from these experiments. The relatively higher gain in the soluble nitrogen in the wet samples is evidently due to the retentive action of the moisture (1942 a) postulated before; further elucidation of this factor will follow in another paper to be published subsequently. Even in this instance, this retentive action is calculable in terms of soluble nitrogen, and the slight differences in the values are attributable to metabolic activities of bacteria. In the water logged samples, still another factor come into play; this is the partial anæobiosis afforded by the water. This has resulted in a greater loss in the total of the inoculated and the soluble of the sterile samples. There is with this a tremendous gain in the soluble of the inoculated, obviously due to the bacterial origin.

Now a word must be said about the viability of this bacterium in the soil under the experimental conditions. Houston's report (1898) indicates the low resistance of this species; in our experiments we found that this organism does not live for 30 days in the dry sample exposed to direct sunlight; but in the semi-saturated and water logged

soils, slight growth was evident, suggesting thereby its resistance to sunlight. The growth was light brown in contrast to the normal rosy-red. Under diffused light and in darkness the organism could live in all the samples for 30 days, the growth in the wet samples being more luxuriant and normally pigmented than from the corresponding dry samples.

2. DIFFUSED LIGHT

Losses in Nitrogen contents expressed in p.p.m. of the soil

The +ve sign before the figures indicates a gain in Nitrogen.

Moisture Condition of the Soil	Inoculated Set		Sterile Set	
	Total N.	Soluble N.	Total N.	Soluble N.
Dry	175.84	+87.64	87.04	60.68
Semi-saturated	0	+65.80	44.24	24.26
Water logged	120.96	+87.64	129.40	24.26

Conclusions.—The greater losses here are attributable to the better chemical action as evidenced from the sterile samples; better opportunities were afforded to the bacterial action, and this has resulted in greater losses in the total nitrogen, the semi-saturated sample affording an exception. The relatively smaller losses in the moist, as compared with the dry, afford in this instance too for the calculation of the retentive action of moisture. The most conspicuous factor is the increase in water soluble nitrogen and that too (in one case) despite the losses indicated in the sterile samples. The observation that no loss had taken place in the semi-saturated total leads one to the conclusion that this must have been due to the fixation of nitrogen by the bacterium. The water logged sample affords actually a definite proof in favour of this process; for the gain recorded in the soluble (inoculated) together with the results in the other three samples lead only to this conclusion. This is further supported by the fact that in this, as well as other samples exposed under darkness the wet samples of the soil gave luxuriant and normal growth of this organism even after an exposure of one month.

3. DARKNESS

Losses in Nitrogen contents expressed in p.p.m. of the soil

The +ve sign before the figures indicates a gain in Nitrogen.

Moisture Condition of the Soil	Inoculated Set		Sterile Set	
	Total N.	Soluble N.	Total N.	Soluble N.
Dry	0	+65.80	50.66	18.88
Semi-saturated	0	+87.64	186.56	56.28
Water logged	44.24	+165.00	106.00	24.26

Conclusions.—The probability of nitrogen fixation is made more than obvious in these figures obtained for bacterial and corresponding chemical action sets. The value of moisture in the retention of soluble nitrogen is emphasized. The increase in water soluble nitrogen (whether due to conversion of the insoluble in the soluble form or due to accumulation of the soluble occasioned by the nitrogen fixation) is clearly indicated. The beneficial influence of darkness on the nitrogen status is brought to prominence and above all the retentive action of moisture and the desirability of *S. marcescens* in the soil for its nitrogen status is elucidated.

SUMMARY

1. *Serratia marcescens* appears to have a significant influence in the nitrogen status of soil in so far as it increases the water soluble nitrogen.

2. The increase in the soluble nitrogen appears to be mainly due to nitrogen fixation by this species.

3. Semi-saturation of the soil by water is undeniably beneficial to the nitrogen retention in soil.

4. *S. marcescens* can live in soil in all the samples of the soil for 30 days, the dry sample exposed to direct sunlight being the only exception.

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2. The Influence of *Bacillus subtilis* in the Nitrogen Status of Soil

IN the previous communication the influence of *S. marcescens* was the subject of study, and all the procedures and methods outlined therein were also rigidly followed in this case. The only difference was that in this instance *B. subtilis*, an organism absolutely different in morphological, staining and physiological characters was employed. It must also be pointed out in this connection that the spore-bearers are the most active group of bacteria in soils and *B. subtilis*, which is the type species of the aerobic spore-bearing bacilli, is indeed one of the most powerful organisms as may be judged from its character. Besides being a strong starch hydrolyser, this species has been found by König (1903) to be a very powerful protein decomposer forming any number of intermediate products. The general properties of the two organisms being widely different, it is not surprising to find great differences in the results obtained.

After the preparation of the 36 experimental samples of the soil (the same soil as used in the previous instance) as detailed out in the previous paper, 18 of the samples constituting the "inoculated" series were each inoculated with 0.1 cc. of a young *B. subtilis* suspension, numbering 246,600,000 cells per cc. The flasks were exposed to different light-weather conditions and at the end of 30 days examined for nitrogen contents and the viability of the bacteria. The results obtained are reported below.

1. DIRECT SUNLIGHT

Losses in Nitrogen contents expressed in p.p.m. of the soil

The +ve sign before the figures indicates a gain in Nitrogen.

Moisture Condition of the Soil	Inoculated Set		Sterile Set	
	Total N.	Soluble N.	Total N.	Soluble N.
Dry	110.04	0	105.40	30.34
Semi-saturated	110.04	+21.60	64.12	10.40
Water logged	219.80	+65.80	53.78	38.00

Conclusions.—The results indicate that in the dry state this organism has no special role to play in depleting the total nitrogen of the soil. However the loss averted in the soluble nitrogen of the inoculated set indicates that this organism has either exerted a "protective" action on the soluble nitrogen as evidenced in the studies with cellulose (1942) or some soluble nitrogen has been produced from the insoluble form. Both the activities appear to be the case as the other inoculated experiments will indicate.

In the semi-saturated sample a greater loss is evident in the inoculated sample as compared to the corresponding sterile one and this is a clear evidence of the *B. subtilis* activity. From the relatively lower loss in sterile set here as compared to the dry sample, the retentive

action of moisture on the soluble nitrogen becomes evident. As a matter of fact, as we have done repeatedly, the smaller loss is attributable to the retentive action of the moisture and this is calculable with exactness in many a case. In this experiment, to indicate the general trend of the effect, calculations are made and tabulated below :

SUNLIGHT : SOLUBLE NITROGEN

The +ve sign before the figures indicates a *gain* in Nitrogen.

Gain or Loss in	<i>B. subtilis</i> Inoculated	Sterile
Dry sample	0	30.34
Semi-saturated sample ..	+21.60	10.40
Difference	21.60	19.94

This is in clear evidence of the retentive action of moisture on holding back the soluble nitrogen of the soil to a tune of some 20 p.p.m. during the course of 30 days.

Coming now to the water logged samples we see that great loss has taken place in the total nitrogen of the inoculated series and this is clearly attributable to the bacterial activity. The insoluble nitrogen is being continuously changed into soluble form and lost. Some of course is utilized for building up of the cell-material. The over-all picture however shows an increase in soluble nitrogen. The growth of bacilli was found heaviest in this case (as evidenced from the cultural studies) and therefore the greater losses cannot be attributed to any other factor. Besides, it is well known that under certain conditions, the addition of organic matter, straw, etc. (charged with *B. subtilis*) into the soil may result in the loss of soil fertility presumably due to the nitrate reduction and other activities.

2. DIFFUSED LIGHT

Losses in Nitrogen contents expressed in p.p.m. of the soil

The +ve sign before the figures indicates a *gain* in Nitrogen.

Moisture Condition of the Soil	Inoculated Set		Sterile Set	
	Total N.	Soluble N.	Total N.	Soluble N.
Dry	77.28	+31.60	87.04	60.68
Semi-saturated	44.24	+44.00	44.24	24.26
Water logged	44.24	+44.00	129.40	24.26

Conclusions.—In the inoculated dry samples the relatively small loss is evident ; this is surprising when we come to think that this smaller loss took place in spite of chemical agencies which deplete the soil even in the sterile condition. We have in a previous paper (1942) actually reported the greater loss due to the light effect and in another (1942) the protective action of cellulose. These two factors are presumably responsible for a smaller loss in the inoculated samples in this instance.

Actually, these experiments afford an opportunity to examine the exact nature of light rays on soluble nitrogen. Comparing the dry samples in this case with those in the previous chart (No. 1) we can derive the effect of light rays in terms of nitrogen loss. The condition holds good, we have noticed, in many instances.

Experimentally it is as follows :—

DRY SAMPLES : LOSS IN NITROGEN

Light		Diffused Light	
Total Nitrogen	Soluble Nitrogen	Total Nitrogen	Soluble Nitrogen
110.04	0	77.28	+31.60 (Gain)

The difference in the total nitrogen is 32.76 ($110.04 - 77.28 = 32.76$) p.p.m. In the soluble nitrogen it is 31.60 (the gain recorded) p.p.m. The loss averted in the soluble is as a result of soluble nitrogen formed by bacteria from the insoluble. Under diffused light there is actually a gain of 31.60 parts which corresponds, within experimental errors, with the total amount saved from the total nitrogen sample in the diffused light, viz., 32.76 parts. So approximately the sunlight alone (presumably heat also) can deplete the soil of its nitrogen, and in this instance it amounts to about 32 p.p.m. during the course of 30 days. That the nitrogen is lost in the soil has been shown in the past by the present authors as well as by Fazal-ud-uddin (1934).

In the semi-saturated conditions where the bacilli had grown to enormous numbers we observe a smaller loss. This is in conformity with our results reported from time to time that moisture has a retentive action on soluble nitrogen. Same amount of loss is seen in both the sterile and the inoculated with regards to the total nitrogen. The increase in the soluble in the inoculated set is due to the conversion of insoluble nitrogen in the soluble form. The gain recorded here together with the loss averted ($+44.00 + 24.26 = 68.26$) gives a rough measure of the total activity of *B. subtilis* on insoluble nitrogen, from the point of view of its conversion of the insoluble to the soluble form.

Now we come to the water logged samples. In spite of its denitrification activities, *B. subtilis* shows here a smaller loss ; this, together with the increase in water soluble nitrogen cannot be explained on any other basis than the "protective" action of *B. subtilis* and for which we have seen some evidences before. The relatively smaller loss in the inoculated and the greater loss in the sterile looks anomalous, but it should be noted that better saturation of CO_2 is possible in the dark (and cool) place and that water-logging afforded this opportunity. In the inoculated on the other hand, ammonia production is definitely possible by deamination and this could only result in forming ammonium carbonate rather than a direct action of CO_2 on soil nitrogen. Besides the anaerobic conditions would prevent nitrification (photo chemical) and this means the chances of denitrification are also minimized.

3. DARKNESS

Losses in Nitrogen contents expressed in p.p.m. of the soil

The +ve sign before the figures indicates a gain in Nitrogen.

Moisture Condition of the Soil	Inoculated Set		Sterile Set	
	Total N.	Soluble N.	Total N.	Soluble N.
Dry	64.34	0	50.66	18.88
Semi-saturated	44.24	22.12	186.56	56.28
Water logged	175.84	0	106.00	24.26

Conclusions.—In the dry sample the loss is definitely less than that recorded for sunlight or diffused light ; thus the destructive action of light rays is made more than evident. Under diffused light condition there was however a gain in soluble nitrogen of the inoculated sample, but that gain is not evident here. In the case of semi-saturated samples here a further striking point is the enormous loss in the sterile sample and the relatively small loss in the inoculated. The postulated “protective” action of *B. subtilis* thus asserts itself. The strange phenomenon however is the loss in soluble nitrogen of the semi-saturated sample as compared with the other two samples wherein the nitrogen level was maintained even after an exposure of one month. This cannot be easily explained from these experiments unless we presume the greater loss to be occasioned by chemical agencies ; towards this there is considerable evidence as may be observed from the losses recorded for the corresponding sterile series. The greater loss in the water logged is clearly attributable to the bacterial activities.

SUMMARY

1. *B. subtilis* is most active in bringing about nitrogen fluctuations in soil under the influence of direct sunlight where it thrives for 30 days.
2. *B. subtilis* converts the insoluble nitrogen into soluble form and maintains the soluble nitrogen level, or even increases it.
3. Direct sunlight and darkness are more detrimental to soil nitrogen than diffused light when the soil has *B. subtilis* in it.
4. *B. subtilis* exerts a “protective” action against the “weathering” of the soil Nitrogen.
5. The exact mechanism of the “protective” action cannot be explained from the fragmentary data available at present.

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SOME OBSERVATIONS ON THE SPORELINGS AND ADULT PLANTS OF *MARSILEA QUADRIFOLIA* Linn.

BY T. S. MAHABALE AND G. H. GORJI,

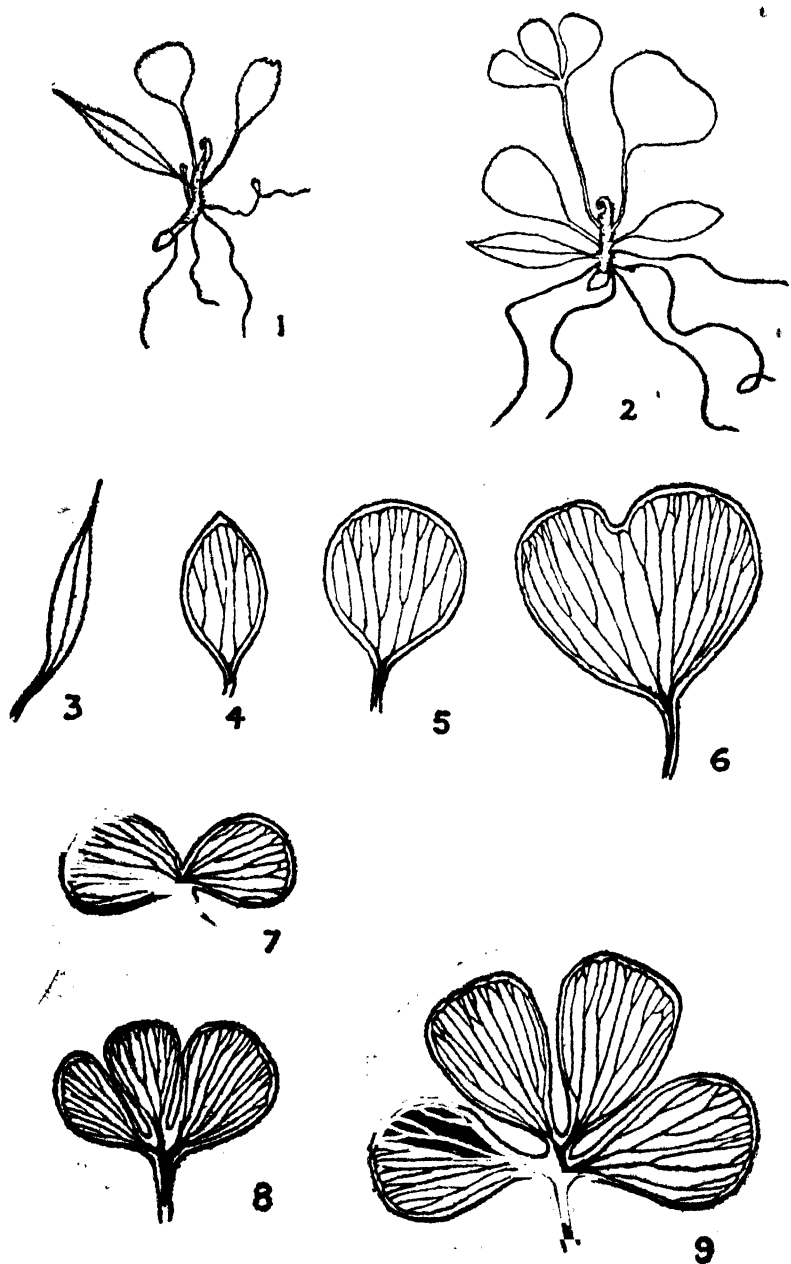
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INTRODUCTION

TWO species of *Marsilea* found in the vicinity of Ahmedabad were identified to be *M. quadrifolia* Linn. and *M. minuta* Linn. by the authorities of the Royal Botanic Gardens Kew and Calcutta. Of the two species *M. quadrifolia* is much more common than the other and thrives best in the temporary ponds formed after the monsoons. It produces sporocarps by the end of December when most of the ponds get dried up. Quite a large number of sporocarps along with rhizomes are left at the bottom of the ponds in summer and sprout again next year after the rains have set in. The mucilaginous cords come out from the sporocarps bearing sori and the germ plants are produced in about 20 days. Many such sporelings of *M. quadrifolia* were collected by the senior author in July 1941 and were given to the junior author for study. On consulting the literature it was found that the morphology or anatomy of these in any of the Indian species of the genus have not been described and hence it was thought worthwhile to record the observations made on them along those made on the leaves of the adult plants of the same species.

THE SPORELINGS

Figs. 1 and 2 show two typical sporelings of the species and the morphology of the leaflets found on them is shown in Figs. 3-9. It is well known that the shape of the adult leaf in many ferns is attained through a succession of juvenile forms. These have been described in *Osmunda*, *Aneimia*, *Pteris*, *Botrychium*, *Helminthostachys*, *Matonia*, *Dipteris*, etc., by Goebel (1904), Chandler (1905), Stephenson (1907), De Bruyn (1911), Gwynne-Vaughan (1911), Bower (1916, 1923), Lang (1924) and others. They have also been described in a species of *Marsilea*, *M. Ernesti* by Braun (1870) many years ago. A careful comparison of the material collected with the observations made by others brought out some stages which have not been previously recorded and hence these will be described in detail here.



Figs. 1-9. *Marsilea quadrifolia* Linn. Sporelings and juvenile leaves $\times 4$.

Figs. 1 and 2. Two sporelings attached to spore. Figs. 3-6. First to fourth successive leaves on a young plant. Figs. 7 and 8. Fifth successive leaf. Fig. 9 Sixth leaf on a germ plant.

A. *Juvenile leaves*.—The leaf of *Marsilea* is not quadrifoliate *ab initio*. The young sporelings show heterophylly beginning with a simple acicular or lanceolate leaf (Figs. 1-3) and end in a quadrifoliate leaf characteristic of the adult plant (Fig. 11). The first leaf on the germ plant is either acicular or lanceolate or linear-lanceolate (Figs. 1 and 3). The second, third and fourth leaves in succession are also simple and have respectively ovate, spatulate, and lobed lamina with a small notch at its apex (Figs. 4-6). The fifth leaf on the germ plant is generally bi-foliate (Fig. 7) but at times trifoliate (Fig. 8). Strangely enough in a recent study of the "seedlings" of *Regnellidium diphyllum* Higinbotham (1942) has found more or less similar stages which culminate in a bifoliate leaf in that genus and stop there. The adult leaf in *Regnellidium*¹ is bifoliate (Fig. 28) but sometimes one comes across a slightly altered form as shown in Fig. 29. The trifoliate leaves noticed here either in the juvenile stages or in the adult plants as those shown in Fig. 17 have not been depicted either by Brahn (1870) or by Bower (1923). The significance of the trifoliate leaves lies in the fact that such a trifoliate condition as a purely transitionary form is noticeable in many species of *Aneimia*, and *Lygodium* belonging to Schizæaceæ to which the Marsileaceæ is said to be allied, and in the "seedlings" of *Osmunda regalis*, *Matonia pectinata*, *Botrychium virginianum*, and *Helminthostachys zeylanica*. The sixth leaf on the germ plant is four-lobed with pinnæ incompletely separated and shows asymmetrical dichotomy thrice (Fig. 9). All other leaves after this stage are quadrifoliate.

B. *The venation of juvenile leaves*.—The venation in all leaves whether juvenile or adult is netted (Figs. 4-9 and Fig. 21), and shows progressive dichotomy of the leaf trace, symmetrical (Figs. 4-7) or asymmetrical (Figs. 8 and 9). It shows cross connections and anastomoses at the margin of the leaf (Figs. 6-9 and 21). This is generally believed to be due to the expanding lamina of the leaf.

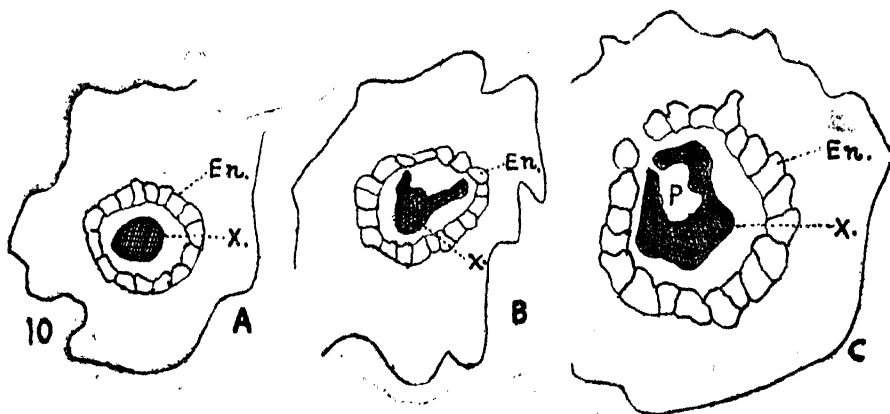
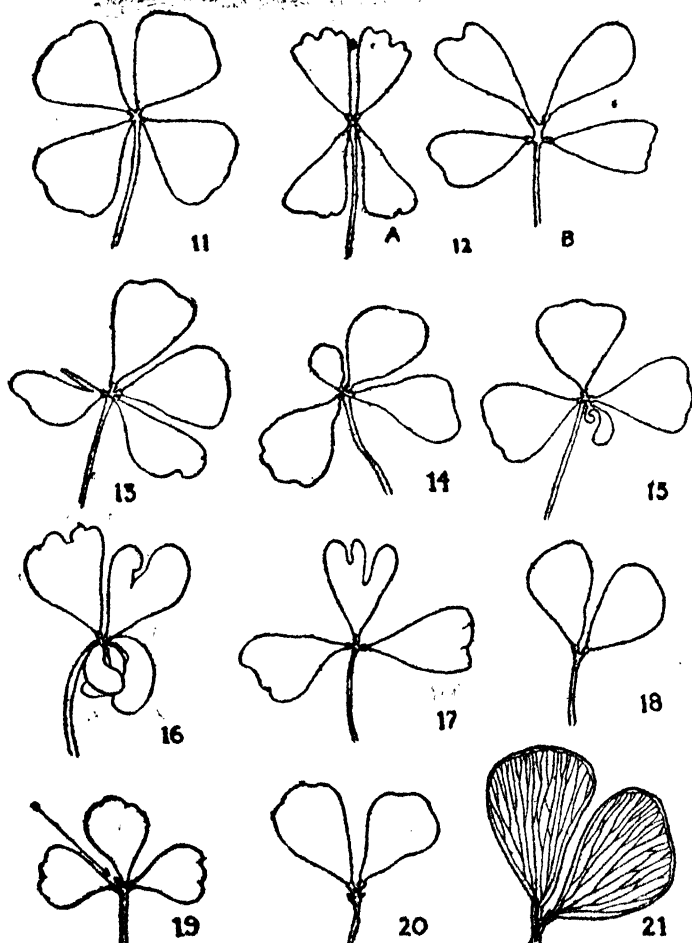


Fig. 10. Stages in the stelar transition in the stem of a germ plant of *Marsilea quadrifolia* Linn. from protostele to amphiphloic siphonostele $\times 16$.

En — Outer endodermis ; X — Xylem ; P — Pith.

¹ I am thankful to Professor B. Sahni for the material of *Regnellidium* who has successfully introduced this plant from Brazil into India and it is growing quite well in his gardens at Almora and in the University Botanic Gardens at Lucknow.

C. *The stele in the stem of the germ plant.*—The adult stem of *Marsilea* is dorsiventral and has an amphiphloic siphonostele. The germ plants on the contrary are not dorsiventral in the beginning but rather erect (Fig. 2) and also do not possess amphiphloic siphonostele (Fig. 10). A study of the serial sections of the stem of the germ plants showed that at the base of the young stem a little below the first leaf, the stele consists of a solid core of xylem with a few tracheids only (Fig. 10 A). This strand gets medullated at the first leaf gap and is converted into an irregular or regular semilunar core of xylem cells perforated by pith in the middle (Fig. 10 B). The leaf traces to the second and third leaf are given out alternately, widening the leaf gap, and the endodermis



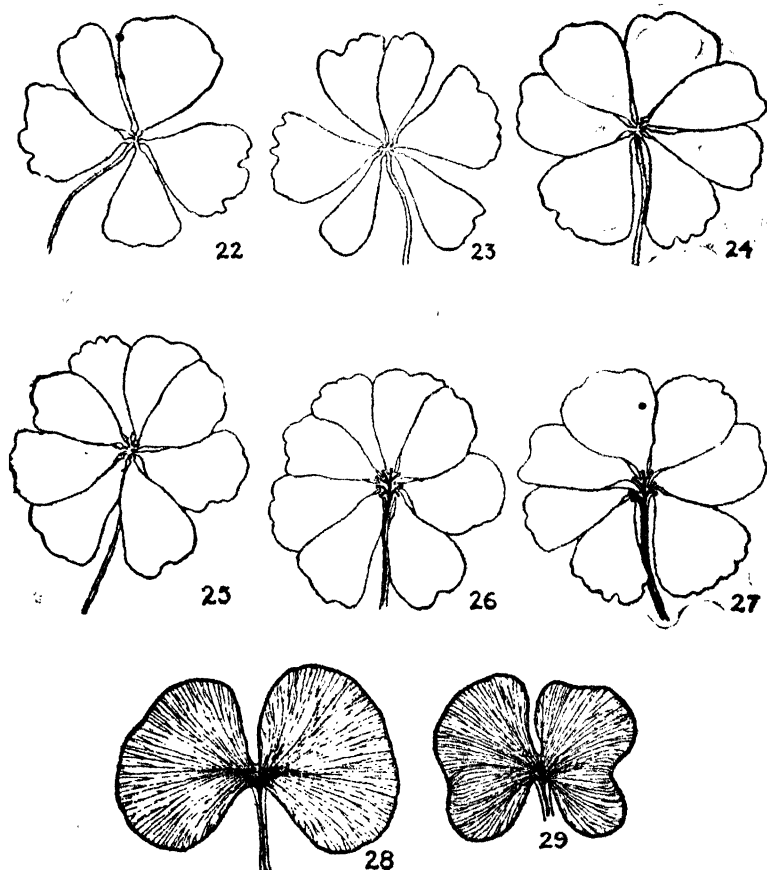
Figs. 11-21. Adult leaves of *Marsilea quadrifolia* Linn. \times N. S.

Fig. 11. A typical quadrifoliate leaf. Fig. 12. A and B. Two leaves in which the two pairs of leaflets are arranged in the same plane. Figs. 13-15. Leaves with one small pinna. Fig. 16. A leaf with five pinnae. Fig. 17. A leaf with three pinnae. Fig. 18. A leaf with two pinnae. Fig. 19. An abnormal leaf with three pinnae and a spine indicated by the arrow. Fig. 20. A leaf with two pinnae and two spines below them. Fig. 21. The network of veins in the bifoliate leaf shown in Fig. 18 magnified $\times 2$.

comes to lie on the inner side also. After the fourth leaf gap the structure of the rhizome becomes distinctly dorsiventral and forms a solenostele which persists throughout the life of the plant in the adult stem.

THE ADULT LEAF

The adult leaf of *M. quadrifolia* and also in all other species consists of two pairs of leaflets arranged one over the other in a decussate manner (Fig. 11). This arrangement of the pinnae, however, is sometimes altered as shown in Fig. 12 A and B by the arrangement of both the pairs of pinnae lying in the same plane. Occasionally the shape, size, and number also of the adult leaflets vary in normal and healthy leaves and one comes across such specimens as are shown in Figs. 13-18.



Figs. 22-27. Multifoliate leaves of *Marsilea quadrifolia* Linn. collected at Amrapara, Bihar. \times N. S.

Fig. 22. A leaf with five pinnae. Fig. 23. A leaf with six pinnae. Fig. 24. A leaf with seven pinnae. Fig. 25. A leaf with eight pinnae. Figs. 26 and 27. Leaves with eight and seven pinnae shown on the dorsal surface to show the dichotomy of the leaf trace on the abaxial side.

Figs. 28 and 29. Two adult leaves of *Regnellidium diphyllum* Lind. $\times \frac{1}{2}$ N. S. Note the slightly fissured leaflet in Fig. 29.

Of these, the specimens in Figs. 13-15 had three large leaflets and one small leaflet, whereas the specimen shown in Fig. 16 had five leaflets, three small proximal ones and two large distal ones. Generally the proximal pair of leaflets is smaller than the distal ones. In the leaf shown in Fig. 17, there are three leaflets and in the one shown in Fig. 18 there are only two, such as those that were noticed in the juvenile stages of the plant (Cf. Figs. 17, 18 with Figs. 7 and 8). In the specimen shown in Fig. 19, one of the leaflets in the proximal pair has been replaced by a small tooth resembling the one found on the adaxial surface of the sporocarp; whereas in the specimen shown in Fig. 20, both the leaflets of the proximal pair have been replaced by two small spines or teeth. On clearing these in xylol, it was noticed that they had a small vascular trace. Evidently these are rather curious structures in the vegetative leaves of *Marsilea*.

In some of the leaves of the same species, recently collected by one of us³ (T. S. M.) at Amarapara in the Santhal Pergunnah, Bihar, there were 5, 6, 7 and even 8 leaflets in some adult leaves (Figs. 22-27). The vascular supply of the 7— and 8—leaved forms clearly showed that 3 or 4 pairs of leaflets were formed by the process of repeated symmetrical or asymmetrical dichotomy of the leaf trace in a scorpioid manner, notwithstanding their apparently whorled appearance (Cf. Figs. 24 and 25 and 26 and 27). In these leaves the pairs of leaflets were very closely arranged and due to their large number gave an impression of a whorl of leaflets arranged on the petiole, which however is not true (see Figs. 26 and 27). To the best of our knowledge, leaves with 3, 5, 7 or 8 leaflets have not so far been recorded. Velenovsky (1905) has figured a leaf with 3 pairs of leaflets one above the other like the two pairs in the specimen shown in Fig. 12B, but the arrangement of leaflets in the present case of 3-, 6-, 7-, or 8- leaved forms was distinctly scorpioid. Possibly the ancestors of the Marsileaceae were plants with large leaves bearing many pairs of pinnae arranged in a scorpioid manner from which the quadrifoliate leaf of the living genus *Marsilea* has been derived by the process of reduction.

From the study of the above facts, it is quite clear

(i) that the leaves in their ontogeny are heterophyllous, the quadrifoliate condition being the result of asymmetrical dichotomy of the leaf trace ;

(ii) that the number of leaflets in an adult leaf may be 3, 5, 6, 7 or 8 ; and

(iii) that one or both the leaflets in the lower pair of pinnae in a leaf may be replaced by small teeth-like projections or spines similar to those on the sporocarp.

³ These were found in a small pond by the riverside at Amarapara and were perfectly healthy. In about half an hour not less than 12 of them were collected.

THEORETICAL CONSIDERATIONS

Two rival opinions on the formation of such juvenile leaves are held among others by Bower (1923) and by Goebel (1900). According to Goebel (1900) these leaves are *arrested* formations; as by starving the plants and then cultivating them on a substratum deficient in necessary food material, it is possible to produce a form of leaf which is considered to be found in the juvenile state only. From this Goebel (1900) suggested, that such juvenile leaves merely represent ill-fed or *arrested organs*. But as against this view, it may be stated that the present leaves showing shapes or number other than the usual ones, although small in size, were perfectly healthy and had no arrested apex or an apical cell at their tips. It is difficult, therefore, to look upon these as arrested organs. Possibly as Bower (1923) maintains they represent successive stages in the ontogeny of the leaf, following increase in the size and form of the plant. Viewed in this light the bifoliate, trifoliate or multifoliate leaves, sometimes noticeable in the adult plants, are to be considered as examples of morphological reversion.

This interpretation gains some further ground from the fact that the first cotyledonary leaf of *Marsilea* and the monotypic Brazilian genus *Regnellidium* are acicular or linear like the adult leaf of *Pilularia*; the fifth leaf on the germ plant of *Marsilea* and the adult leaf of *Regnellidium* is bifoliate. In some other "seedlings" of *Marsilea* the fifth leaf is trifoliate as in *Aneimia* and other members of the Schizaeaceae. The adult leaf of *Marsilea* no doubt progresses beyond this stage, but it is possible that it may have been derived from an ancestral form having a much larger compound leaf with many pinnae. All these stages, therefore, illustrate the principal of "Recapitulation," a conclusion, which is also borne out by the consideration of the vascular anatomy of the stele in the stem of the young plant.

The other burning question in the morphology of *Marsilea* is the nature of its sporocarp. Many competent authors such as Johnson (1898a), Goebel (1904), Shattuck (1910), Eames (1936), Smith (1938) hold that the sporocarp in *Marsilea* is foliar in nature, the clearest evidence for which is supplied by the study of its vascular anatomy. It is supposed to have been formed by the fusion of the distal pair of pinnae with the lower pair of pinnae suppressed. The suppressed leaflets are represented on the sporocarp by small teeth or tubercles. In most of the species of *Marsilea* the lower tooth is stout and the upper one is slender, though in some rare species both the teeth are said to be absent. In *Pilularia* the lower teeth form a small rounded protuberance at the base of the sporocarp, to which a vascular supply has been noticed by Johnson (1898b). The upper tooth is absent in *Pilularia*. In *Regnellidium* both these teeth are absent but there is a distinct scarlet-coloured raphe on the sporocarp. The importance of this structure in interpreting the morphological nature of the sporocarp therefore is obvious. Apart from the vascular anatomy, the facts about which are wellknown, the present study adds one more point in favour of the foliar theory, namely, that one or both the leaflets in the lower pair of pinnae in a quadrifoliate leaf may be replaced by a small spine or spines as those on the sporocarp. This confirms the foliar nature of the sporocarp as the teeth similar to those on the sporocarp are found in the place of the lower pair of pinnae in a leaf.

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STUDIES IN THE ECOLOGY OF MANGROVES

THE HYDROGEN-ION CONCENTRATION OF THE SEA-WATER, SOIL-SOLUTION AND THE LEAF CELL-SAP OF THE MANGROVES

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INTRODUCTION

- (A) Methods
- (B) Results and Discussion
 - (a) Seasonal Variations
 - (b) Effect of Tides on the pH
 - (c) Difference in the pH of the Cell-sap of Adult and Young Leaves
- (C) Conclusions
- (D) Acknowledgement
- (E) Bibliography

THE H-ion concentration gives an idea of the acidic or basic nature of the substance analysed. The sodium chloride-content of the cell-sap of the mangrove leaves is responsible for the changes and nature of the osmotic pressure of the sap.

Not only is the H-ion concentration of the cell-sap important but also that of the sea-water, for the distribution of sea and salt marsh vegetation is dependent upon it. This view is expressed by Hoyt (9) in his study of the effect of light and of the turbidity of water on the vertical distribution of marine algae at Beaufort. The effect of light and of the H-ion concentration on the growth of certain algae was recorded by Gail (7). But there still remains a large amount of work to be done on sea-water. The pH value of sea-water depends on its oxygen content as shown by Helland-Hansen (8). The photosynthetic activity of the algal flora in summer raises the oxygen content of the sea water and consequently its pH value is on the alkaline side during the summer months. The high alkalinity of sea water is due to the photosynthetic activity of the Plankton and attached algae. Results obtained by McCledon (11) showed a lower pH in the morning and a higher in the evening of sea water. It is also dependent upon temperature as shown by the same author.

According to Mayer (10) for every fall of one degree in the temperature there is a corresponding fall of 0.01 in the pH of water. It has also been found that the presence of magnesium hydroxide in sea water raises its pH value to a higher degree than calcium hydroxide, though the OH-ion concentration produced by the former is less than that of the latter. This may perhaps be due to the smaller solubility of calcium carbonate.

According to Atkins (1), who has extensively studied the H-ion concentration of sea-water at Plymouth, the sea-water may become as alkaline as pH 9.7 due to very active photosynthesis. This it does in virtue of the presence of magnesium salts since the limiting pH value of magnesium carbonate is pH 10.0 ; the same holds good for magnesium hydroxide. Calcium carbonate in the form of pure calcite, gives a limiting value of pH 9.0. The alkalinity of the water of the Sound varies slightly with the tide and a drop of pH 0.50 may be observed between high and low water, i.e., the pH value of sea-water at Sound changes between the high and the low tide. The H-ion concentration of sea-water surrounding algae shows more alkalinity than the general mass of the water. The H-ion concentration of sea-water shows variations during the year; thus in July the water of the Sound is definitely more alkaline than that of the open sea, while from August to January the condition is reversed. In the open sea between July and December the pH value varies from pH 8.27 to 8.14, in April it is pH 8.24.

The same author found that pH value at all stations rose from December and January to maximum in May and August, the former being more marked. A well defined minimum was observed in July. In winter the Sound water was less alkaline than that of the sea. In summer the difference was not so marked.

Similarly the changes in the salinity owing to the influence of the river water were observed. Both the temperature and the pH value show that the vertical mixing of the water is at all times thorough at places not well out to sea, whereas at stations far away inwards, the phenomenon is less marked. According to him this appears to be a factor of considerable biological importance.

The maximum pH in May corresponds with the maximum average number of hours of sunshine rather than with the length of the day, which reaches a maximum in June.

In winter, pH value and temperature lead to a carbon dioxide estimate of 0.17 mm., which in May is reduced to 0.13 mm. A well marked maximum in May, followed by a depression in June and July 1922 is not found in 1923 during summer months of which the water increased in alkalinity, until August, when it slowly decreased. This appears to be due to the absence of stormy and wet weather in June and July 1923. In a general way the pH maxima may be correlated with the diatom maxima in early summer and in autumn.

Cooper and Pasha (4 & 5) while studying osmotic pressure and H-ion concentration of the sea weeds in relation to those of sea-water near Bombay, found that the H-ion concentration of the sea-water is one of the important factors which determine the distribution of algal forms. In this study they used the indicator method as developed by Clark (3) for the H-ion concentration of sea-water and cell-sap. They found the pH of sea-water between 8.21 to 8.31 and a variation was obtained of the sea water-in-pools from 8.0 to 8.21. The pH value of the cell-sap of all the algal species studied was remarkably uniform. It only fluctuated between 6.6 to 7.0, showing thereby that the cell-sap of the algae was nearly neutral. This is a point of importance, according to them, as generally, the cell-sap of higher plants is acidic in nature. The same authors account for the lesser acidity of the cell-sap to the alkalinity of the sea-water in which they remain immersed.

It will be seen from the above review that a certain amount of work has been done on the effect of external factors on the growth and distribution of the marine algae. In spite of the importance of the H-ion study no determination of the H-ion concentration of the sea-water in relation to the mangrove vegetation has been made in the tropical seas, and hence it was decided to determine the pH value of the mangrove cell-sap, sea water and soil solution.

METHODS

The detailed methods of extracting the cell-sap, the collection of sea-water samples and the preparation of the soil solution have already been dealt with in our previous paper (2).

The pH of all the three solutions was determined electrometrically as mentioned previously and mean of the three readings taken.

RESULTS AND DISCUSSIONS

Tables 1 and 2 give the pH values of the cell-sap of the leaves of *Avicennia alba* Bl., sea-water and the soil solution of the samples under the same area. The samples that were collected from the Colaba reclamation area for the determination of the chloride-content, were used in the determination of pH of the cell-sap. But in the case of sea-water and soil solutions, separate samples were taken at the same time, as described already, in our previous work (2).

TABLE 1

*Readings of pH values of sea-water, soil solution
and leaf cell-sap of Avicennia alba from Colaba*

(Seasonal Series)

Date	Sea-water	Soil-Solution		Leaf Cell-sap	Season
		in H ₂ O	in KCl		
9-9-36 ..	8.60	7.06	6.92	..	Rainy
30-9-36 ..	8.00	6.91	6.81	..	
14-10-36 ..	8.30	6.80	6.62	..	Cold
30-10-36 ..	8.10	6.78	6.49	..	
21-11-36 ..	8.50	6.70	6.72	..	
18-12-36 ..	8.50	6.70	6.72	..	
29-1-37 ..	8.73	7.08	6.73	..	
27-2-37 ..	8.73	6.78	6.65	5.36	Hot
22-3-37 ..	8.03	6.78	6.61	5.97	
22-4-37 ..	7.89	6.83	6.60	6.22	
18-5-37 ..	8.07	6.83	6.60	6.14	
18-6-37 ..	8.36	7.15	6.46	6.24	Rainy
15-7-37 ..	8.64	7.26	6.76	6.21	
23-8-37 ..	8.16	7.02	6.69	5.86	
23-9-37 ..	8.20	7.15	6.82	5.83	
7-10-37 ..	8.53	6.81	6.64	5.90	Cold
19-11-37 ..	8.45	6.84	6.64	4.50	
8-12-37 ..	8.73	7.03	6.96	5.88	

TABLE 2

*Readings of pH values of sea-water, soil solution
and leaf cell-sap of Avicennia alba from Colaba*

(Weekly Series)

Date	Sea-water	Soil-Solution		Leaf Cell-sap	Season
		in H ₂ O	in KCl		
5-8-39 ..	7.92	6.80	6.76	6.18	Rainy
12-8-39 ..	7.95	7.03	6.62	5.87	
19-8-39 ..	8.68	6.78	6.63	5.78	
2-9-39 ..	8.83	6.78	6.61	5.78	
9-9-39 ..	8.35	6.84	6.81	6.85	
15-9-39 ..	8.35	7.45	6.73	5.96	
23-9-39 ..	7.73	6.86	6.70	5.95	
30-9-39 ..	7.64	7.33	6.70	6.06	
6-10-39 ..	7.81	6.81	6.70	5.68	Cold
13-10-39 ..	8.16	6.77	6.67	6.00	
20-10-39 ..	8.42	7.21	6.72	5.89	
26-10-39 ..	7.95	7.29	6.72	6.20	
2-11-39 ..	8.54	6.83	6.73	5.88	
8-11-39 ..	7.85	6.71	6.81	5.73	
17-11-39 ..	8.20	6.82	6.73	6.11	
23-11-39 ..	7.86	7.11	6.72	5.85	
30-11-39 ..	7.77	6.78	6.85	5.61	
7-12-39 ..	8.06	6.88	6.85	6.01	
14-12-39 ..	8.15	6.69	6.72	6.03	
21-12-39 ..	8.35	6.77	6.72	5.88	
28-12-39 ..	8.54	6.54	6.56	5.95	
4-1-40 ..	8.06	6.75	6.69	5.93	
11-1-40 ..	8.16	6.73	6.62	6.19	
18-1-40 ..	8.20	6.56	6.51	6.08	
22-1-40 ..	7.95	6.68	7.04	5.97	
25-1-40 ..	8.05	6.58	6.64	5.74	
1-2-40 ..	7.66	6.63	6.54	6.07	Hot
8-2-40 ..	7.68	6.50	6.61	6.04	
15-2-40 ..	8.19	6.56	6.63	6.04	
22-2-40 ..	8.52	6.56	6.67	6.03	
29-2-40 ..	8.31	6.56	6.72	6.12	

It will be seen from Tables 1 and 2 and Figs. 1 and 2 that 12 monthly readings from February 1937 to January 1938, and 32 weekly readings from 5th August 1939 to 29th February 1940, of the cell-sap of the adult leaves of *Avicennia alba* and 5 weekly readings of the young leaves, were recorded; while for the sea-water 19 monthly readings from 9th September 1936 to 18th January 1938 and 32 weekly readings from 5th August 1939 to 29th February 1940 were noted. Further 18 monthly readings of the soil solutions in water and KCl (from 9th September 1936 to 18th January 1938) were made, and again 32 weekly readings of the same solutions from 5th August 1939 to 29th February 1940 were noted.

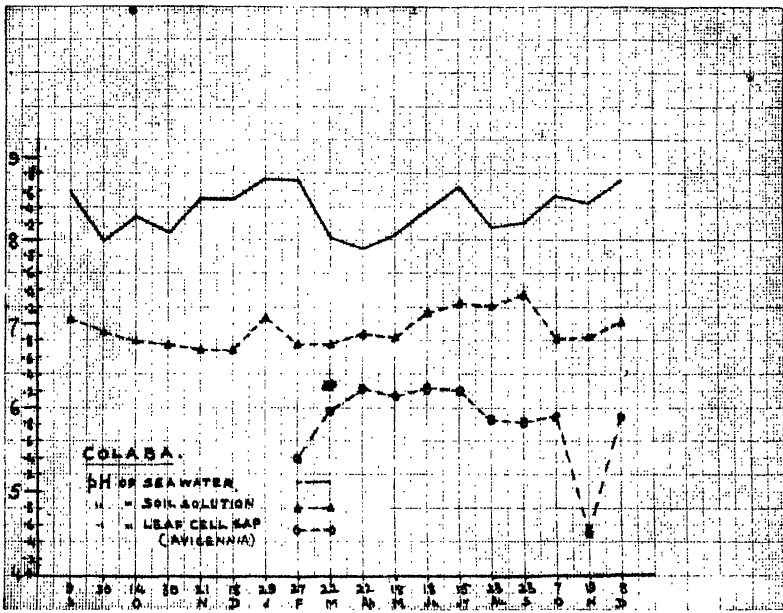


FIG. 1

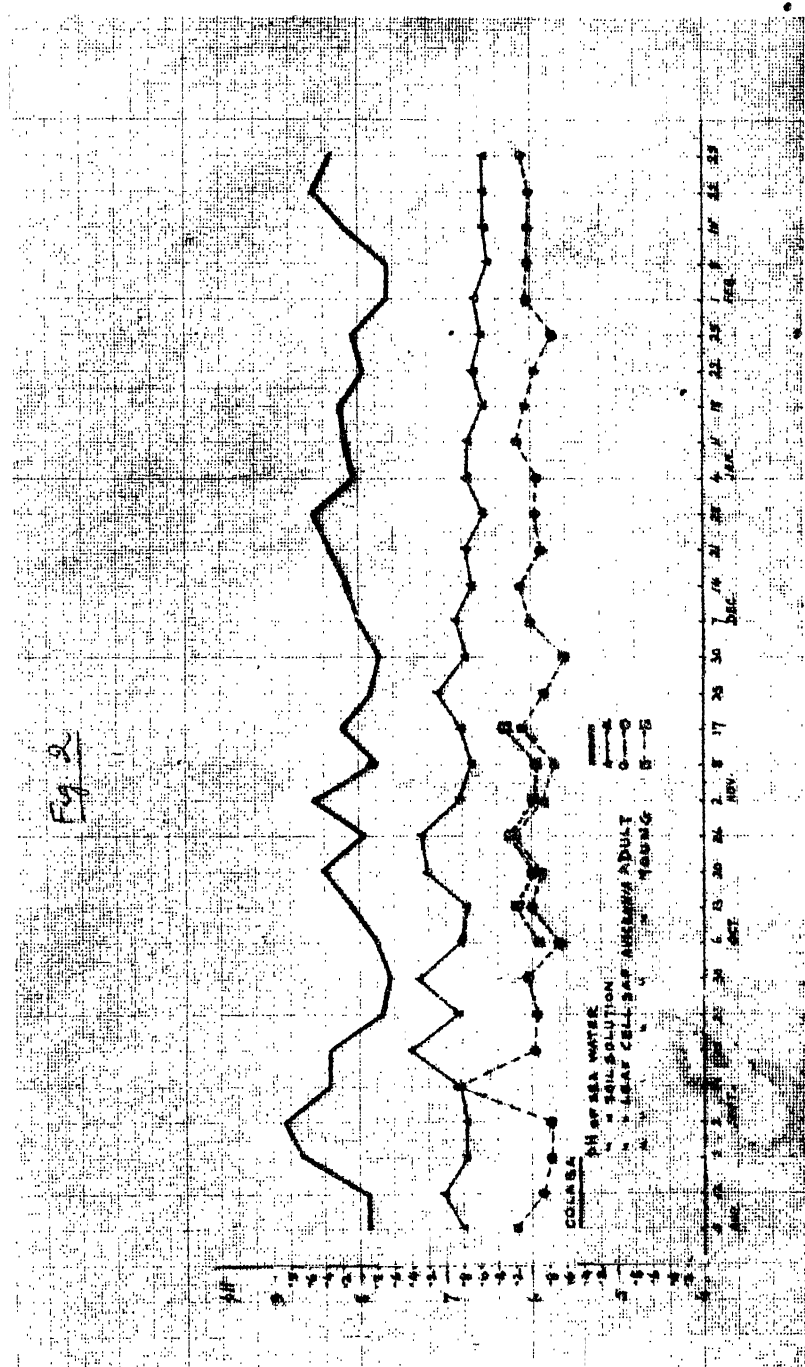


FIG. 2

Seasonal Variations :—It is apparent from Table 3 of the yearly mean, that on the average the pH value of the cell-sap is 5.95, that of sea-water 8.22 and of soil solutions in water and in KCl 6.85 and 6.69 respectively. There is not much difference in the values of the monthly and weekly series.

TABLE 3

(Yearly Mean)

Series	Sea-water	Soil-Solution		Leaf Cell-sap
		in H ₂ O	in KCl	
Monthly ..	8.37	6.93	6.69	5.84
Weekly ..	8.13	6.80	6.70	5.99
Average ..	8.22	6.85	6.69	5.95

From this it is evident that the cell-sap is distinctly acidic, the soil solutions less so or almost neutral as they have pH values very near about 7 and the sea-water is distinctly alkaline with pH more than 8.

The above results for the cell-sap and sea-water confirm those of Cooper and Pasha (4 & 5) and of Atkins (1) who have determined the pH of sea-water at different seasons. But the Hydrogen-ion concentration of these solutions do not merely differ in average yearly values but also in different seasons as can be seen from Table 4.

TABLE 4

Monsoon

Series	Sea-water	Soil-Solution		Leaf Cell-sap
		in H ₂ O	in KCl	
Monthly ..	8.32	7.09	6.74	6.03
Weekly ..	8.18	6.98	6.69	6.05
Average ..	8.24	7.03	6.71	6.05

COLD

Series	Sea-water	Soil-Solution		Leaf Cell-sap
		in H ₂ O	in KCl	
Monthly ..	8.30	6.84	6.69	5.58
Weekly ..	8.12	6.79	6.72	5.95
Average ..	8.23	6.81	6.71	5.88

HOT

Series	Sea-water	Soil-Solution		Leaf Cell-sap
		in H ₂ O	in KCl	
Monthly ..	8.18	6.82	6.61	5.92
Weekly ..	8.07	6.56	6.63	6.06
Average ..	8.12	6.67	6.62	5.99

The monsoon mean value of the cell-sap is 6.05, for the sea-water is 8.24 and for the soil solution in H₂O and in KCl are 7.03 and 6.71 respectively. There is very little difference between the monthly and weekly series of all these solutions. The monsoon values are always higher than of other seasons, i.e., the cell-sap gets less acidic, the soil-solution almost neutral and the sea-water more alkaline. This can be explained on the fact of the dilution of the sea-water near the shores and is supported by Atkin's work (1).

Another reason for change to alkalinity of the sea-water in the monsoon, is that the pH depends also on its oxygen content, as mentioned above by Helland-Hansen (8). According to him the photosynthetic activity of the algal flora at the end of summer, raises the oxygen content of the sea-water and hence its pH. This statement is proved by the present investigation. It is found that near the Colaba Reclamation area, the mangrove vegetation is more often surrounded during low tide by species of green algae, which may be raising the oxygen-content of the sea-water and by their photosynthetic activity may be turning the sea-water more alkaline.

The acidity of the mangrove soil throughout the year, except the monsoon, is according to Doynce and Granville, (6) due to the formation of water soluble compounds, like probably the ferrous-sulphide which is present in the soils in their natural state. The slow oxidation of these soils may be undergoing in the hot season from ferrous to ferric sulphide and then the *sulphide* is hydrolysed to ferric-hydroxide and sulphuric acid. Further the tendency towards acidity of these mangrove soils is due to the liberation of exchangeable hydrogen by the cations present in the salt-water.

Though all the detailed analysis of the mangrove soils, on the lines as described by the same authors, could not be done in the present investigation, the results obtained here clearly confirm their statement namely tendency towards the acidity during these seasons in which the soil is exposed to oxidation.

It is interesting to mark that the average pH values of the cell-sap for the monsoon, the cold and the hot seasons are 6.04, 5.88 and 5.99 respectively (Table 4). This would indicate that in the monsoon the cell-sap becomes less acidic than in other seasons, and this might be explained by saying that in the hot and the cold seasons the gradual change towards acidity corresponds to the accumulation of sodium salts as previously shown (2) and thereby leads to a gradual increase in the osmotic pressure.

• *Effect of Tides on the pH*.—It was shown previously (2, 12) that the tides have an effect on the concentration of the cell-sap of the sea-water and soil-solution. Naturally when the concentration is altered the corresponding changes in pH of the sea-water must take place and this is found to be the case in the present investigation. When the graphs of the tides (2 & 12) and the pH values (Figs. 1 & 2) are compared it is apparent that the latter runs parallel to that of the low tide. That this should be so can be explained on the fact that at low tide the concentration of the sea-water increases as previously shown (2) due to (I) the photosynthetic activity of the plankton and algae (8) and (II) greater surface for evaporation. When the concentration of the sea-water is thus affected, pH also changes correspondingly. But this in turn affects correspondingly the pH concentration of the cell-sap i.e. at low tide the value shifts towards neutral from the acidic side.

On the other hand, the soil-solutions show a tendency towards greater acidity and this is obviously so, as is proved by Doyne (6) for, due to the exposure the mangrove soils tend to become more acidic.

The above conclusions drawn from general graphs (Figs. 1 & 2) are further proved from the following experiments in which the differences due to tides on the same day are recorded.

TABLE 5

pH values

	Sea-water	Soil-Solution		Leaf Cell-sap
		in H ₂ O	in KCl	
High Tide ..	7.95	6.68	7.04	5.97
Low Tide ..	8.20	6.56	6.76	6.17

From the above table 5 it is clear that the tides do exert an influence on the Hydrogen-ion concentration of different solutions. The high tide causes the pH values of the cell-sap, soil-solution and sea-water to decrease and a low tide, to increase.

Difference in pH of the Cell-sap of Adult and Young Leaves.—It will be seen from Table 6 that there is not appreciable difference between the values of the pH of the adult and young leaves. However little difference there may be it is to be noted that in all cases the pH values of the young leaves are always slightly higher than those of the adult ones showing thereby the less acidic nature of the cell-sap; and this is supported by the fact of lesser concentration of the cell-sap (as per our previous work) (2) in the young leaves. The results are given in the following table.

TABLE 6

Date	pH of the Cell-sap of Adult Leaves	pH of the Cell-sap of Young Leaves
6.10.39 ..	5.68	5.92
13.10.39 ..	6.00	6.19
20.10.39 ..	5.89	5.99
26.10.39 ..	6.20	6.24
2.11.39 ..	5.88	5.96
8.11.39 ..	5.73	5.94
17.11.39 ..	6.11	6.32

CONCLUSIONS

(1) As no study was so far made to find out the relationship existing between the pH of the cell-sap, soil solution and sea-water, it was undertaken and forms part of this investigation into the general ecology of the mangrove vegetation of the Bombay and Salsette Islands.

(2) The H-ion concentration of the above solutions were determined electrometrically by the Pehave apparatus of Hartmann and Braun.

(3) After due precautions of extractions, the pH of the cell-sap of the leaves of *Avicennia alba*, samples of soil solution (in H_2O and KCl) and sea-water were determined.

(4) The mean yearly pH values of the above solutions were found respectively to be 5.95, 6.85, 6.69 and 8.22.

(5) The mean values of the same solutions during monsoon are 6.05, 7.03, 6.71 and 8.24; during the cold season are 5.88, 6.81, 6.71 and 8.23 and during the hot season are 5.99, 6.67, 6.62 and 8.12 respectively. The reason why the pH values are high in monsoon than those of other seasons is already explained by saying that due to dilution of the sea-water the corresponding changes occur in the results.

(6) The pH of the cell-sap, soil solution and the sea-water is in the following decreasing order :—

Cell-sap \longrightarrow Soil-solution \longrightarrow Sea-water, i.e., the cell-sap is distinctly acidic, the soil-solution is nearly neutral and the sea-water is distinctly alkaline.

(7) The seasonal and climatic factors like rainfall and temperature, which affect the concentration of the sea-water, soil-solution and the cell-sap, are also responsible for the corresponding changes in the pH of these substances; and this is natural as the pH is dependent upon the concentration.

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BOOK REVIEW

The Dissection of the Crayfish. By R. H. Whitehouse and A. J. Grove. University Tutorial Press, London, 1947.

THIS handy Laboratory guide is the latest in the series of Practical Zoology Manuals written by the authors.

The first chapter gives valuable advice about the Laboratory methods and stresses the importance of making drawings from personal observations and of keeping complete record of work—an advice which is today needed by the students working for our University Examinations.

The treatment of the subject is very helpful as text-book knowledge and simple, clear directions for the manipulations are given along with excellent photographs and labelled diagrams of the successive systems to be exposed, for example, the green gland which is so confusing to the student.

Even though there are some minor differences in the structure of *Astacus* treated in the book and *Panulirus* studied by our students, the book can be conveniently used as a useful laboratory guide to study the animal, as a matter of fact, any animal—as it should be studied by the student.

One cannot but help thinking that good books dealing with Indian Fauna are very few. This book will surely serve as an excellent model for writing laboratory manuals about the Indian types of animals studied in our University.

—S. B. RANADE

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